REMEDIAL INVESTIGATION/FEASIBILITY STUDY (RI/FS) WORK PLAN

FOR THE

R&H OIL/TROPICANA ENERGY SITE
SAN ANTONIO, TEXAS

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LIST OF ACRONYMS

ACM – Asbestos Containing Material
AFB – Air Force Base
AFBCA - Air Force Base Conversion Agency
AFCEE - Air Force Center for Engineering Excellence
ATSDR – Agency for Toxic Substances and Disease Registry
BERA – Baseline Ecological Risk Assessment
BHHRA – Baseline Human Health Risk Assessment
BTEX – Benzene, Toluene, Ethylbenzene, and Xylene
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
COPC – Chemicals of Potential Concern
COPEC – Chemicals of Potential Ecological Concern
CIP – Community Involvement Plan
CSA – City of San Antonio
CSADSD - City of San Antonio Development Services Department
CSM – Conceptual Site Model
DNAPL – Dense non-aqueous Phase Liquid
DO – Dissolved Oxygen
DQO – Data Quality Objective
E&E - Ecology & Environment, Inc.
EDD – Electronic Data Deliverable
EPA – United States Environmental Protection Agency
ERA – Ecological Risk Assessment
ERM – Environmental Resource Management
FS – Feasibility Study
FSP – Field Sampling Plan
GWBZ – Groundwater Bearing Zone
HASP – Health and Safety Plan
HRS – Hazard Ranking System
LNAPL – Light non-aqueous Phase Liquid
MNA – Monitored Natural Attenuation
NAPL – Non-aqueous Phase Liquid
NWI - National Wetland Inventory
NCP – National Contingency Plan
NPL – National Priorities List
ORP – Oxidation-Reduction Potential
OSHA – Occupational Health and Safety Administration
OVM – Organic Vapor Meter
PBW – Pastor, Behling & Wheeler, LLC
PCL – Protective Concentration Level
PDF – Portable Document Format
PHA – Public Health Assessment
PHSA – Potential Historical Source Area
PRG – Preliminary Remediation Goal
PSA – Potential Source Area
QA – Quality Assurance
QAPP – Quality Assurance Project Plan
QC – Quality Control
RI – Remedial Investigation

LIST OF ACRONYMS (continued)

RME – Reasonable Maximum Exposure
RSL – Regional Screening Level
SAALC - San Antonio Air Logistics Center
SAIC - Science Applications International Corporation
SAP – Sampling and Analysis Plan
SAWS - San Antonio Water System
SLERA – Screening-Level Ecological Risk Assessment
SMDP – Scientific Management Decision Point
SOW – Statement of Work
SSO - Site Safety Officer
SVOC – Semivolatile Organic Compound
TCEQ – Texas Commission on Environmental Quality
TDH – Texas Department of Health
TDSHS – Texas Department of State Health Services
TNRCC – Texas Natural Resource Conservation Commission
TPH – Total Petroleum Hydrocarbons
UCL – Upper Confidence Limit
USGS - United States Geologic Survey
VOC – Volatile Organic Compound
VSP – Visual Sample Plan
WP – Work Plan

1.0 INTRODUCTION

The United States Environmental Protection Agency (EPA) proposed the former R&H Oil/Tropicana Energy Site in San Antonio, Bexar County, Texas (the Site) to the National Priorities List (NPL) in June 2001; however, the Site has not been listed on the NPL. On March 12, 2010, the EPA and Respondents entered into an Administrative Settlement Agreement and Order on Consent (Settlement Agreement) requiring the Respondents to conduct a Remedial Investigation and Feasibility Study (RI/FS) for the Site. The Respondents participating in the Settlement Agreement for the RI/FS are:

Bridgestone Americas Tire Operations, LLC
Department of State Health Services
Perkin Elmer Automotive Research, Inc. (f/k/a EG&G Automotive Research (Perkin Elmer, Inc.))
Exxon Mobil Corporation
Flint Group Incorporated
National Radiator Company, a dissolved Texas corporation
BAE Systems Resolution, Inc. (f/k/a Santana Resolution Corporation)
Structural Metals, Inc.

For the purposes of this RI/FS Work Plan, the above Respondents are collectively referred to as the R&H Oil Company Site Group.

This Work Plan (WP) was prepared in accordance with Paragraphs 21 through 26 of the Statement of Work (SOW) for the RI/FS included as Appendix B to the Settlement Agreement. The RI/FS WP was prepared by Pastor, Behling & Wheeler, LLC (PBW), on behalf of the R&H Oil Company Site Group. The WP format and elements have been developed in accordance with EPA RI/FS guidance (EPA, 1988). Figure 1 provides a map of the Site vicinity, while Figure 2 provides a detailed Site map. A scoping phase meeting for the RI/FS was held at the EPA Region VI offices in Dallas, Texas on March 24, 2010. The topics discussed, documents exchanged and action items taken from that meeting are documented in the meeting notes included in Appendix A.

1.1 ISSUES POSED BY THE SITE

Several investigations have been conducted at the Site since impacts were observed in 1980 (see Section 2.4.2). A Hazard Ranking System (HRS) Documentation Record was completed for the Site by the Texas Natural Resource Conservation Commission (TNRCC)(now known as the Texas Commission on Environmental Quality or TCEQ) in 2001 (TNRCC, 2001). This record concluded that "petroleum hydrocarbon-contaminated ground water has been identified in the shallow alluvial aquifer beneath the site" and "hydrocarbon seeps and areas of stained soils were observed in various areas of the site". A Public Health Assessment (PHA) performed for the Site in 2003 (ATSDR, 2003) concluded that the Site "poses no apparent public health hazard". Based on the HRS documentation, EPA requested that an RI/FS be performed at the Site. The overall issue to be addressed by the RI/FS is to evaluate the nature and extent of chemicals of potential concern (COPCs) at/from the Site, assess the risk from these chemicals to human health and the environment, and evaluate potential remedial alternatives.

1.2 OBJECTIVES

Consistent with the EPA guidance and overall issue posed by the Site, the specific objectives of this RI/FS are to: (1) characterize site conditions; (2) evaluate the nature and extent of the COPCs; (3) assess the risks to human health and the environment; (4) identify remedial action objectives for those chemicals and media posing an unacceptable risk; (5) develop preliminary remediation goals (PRGs) to address the remedial action objectives; (6) develop, screen and evaluate potential remedial technologies consistent with the PRGs; (7) examine the potential performance and cost of the remedial alternatives that are being considered; and (8) summarize and present the data so that an appropriate remedy consistent with CERCLA, can be selected by EPA. The RI/FS process is a phased, interactive, and iterative process. The RI and FS are conducted concurrently, and data that are collected in the RI influence the development of remedial alternatives in the FS, which in turn affects the data needs, scope of treatability studies, and additional field investigations.

The objective of the RI/FS WP is to document the decisions and evaluations made during the RI/FS scoping process and present a summary of the work to be performed during the RI/FS. The WP also presents the initial evaluation of existing Site data and background information, and describes the project management team and schedule.

2.0 SITE BACKGROUND AND PHYSICAL SETTING

2.1 SITE DESCRIPTION

The Site area totals approximately six to seven acres and is comprised of two tracts: a northern tract located at 403 Somerset Road and a southern tract located at 507 Somerset Road in San Antonio, Bexar County, Texas (see Figure 1) (the address of the southern tract was formerly listed as 419 Somerset Road in the proposed NPL listing of the site). The northern tract has been previously referred to as the R&H Oil Company and/or the Eldorado Refining and Marketing, Inc. site. The southern tract has been referred to as the Tropicana Energy Company site. Both tracts together are considered "the Site" for the purposes of this RI/FS.

2.2 ENVIRONMENTAL SETTING

2.2.1 <u>Local Land Use</u>

The Site is located approximately five miles southwest of downtown San Antonio. Land use north and west of the Site is primarily commercial/industrial, including the former East Kelly AFB to the west, and multiple light industrial, auto salvage, repair, and/or service station facilities to the northeast and southwest. The Site is bordered to the north by an auto service center and to the west by the Union Pacific Railroad line, an auto repair and parts establishment, and East Kelly AFB. Residential, commercial, and industrial development is present to the south and east, and Somerset Road is adjacent to the Site to the east. U.S. Census data from 1990 indicated a total population of 4,085 within a one mile radius of the Site with 96.6% minority and 52% economically stressed (EPA, 2003).

The City of San Antonio land use zoning classification for the Site is heavy industrial. Specifically, the north tract is zoned as "I-2 – Heavy Industrial District" (CSADSD, 2008), and the south tract is zoned as "I-2 S Heavy Industrial District" with a special City Council approval for a bulk plant and terminal (CSA, 1990). According to the City's Unified Development Code (CSA, 2008), the Heavy Industrial District "accommodates uses that are highly hazardous, environmentally severe in character and/or generate very high volumes of truck traffic."

2.2.2 Ecological Characteristics

A number of Site visits have been conducted from 2006 through 2010 to evaluate existing land use characteristics, observe and characterize wildlife and terrestrial habitats, and for Site maintenance (e.g., fence repair, mowing, etc.) purposes. The Site is surrounded by a security fence. Roughly one-third of the Site is comprised of gravel parking lots, paved road, and extensively re-worked soil and bare patches of dirt. The remaining portion of the Site is a routinely maintained grass lot with several grassy containment berms still present. A few small scrub shrubs/trees have grown along the fence line.

2.2.2.1 Terrestrial Habitats

After the cessation of operations in approximately the late 1980’s or early 1990’s, and performance of EPA removal actions in 2001 to remove equipment and residual materials (see Site history in Section 2.4 below), the Site became overgrown. In 2007, the R&H Oil Company Site Group, through PBW, contracted for repair/upgrade of the Site perimeter fencing and gate system, removal of general debris, cutting of overgrowth, and mowing of the Site. Since that time the Site has been maintained by a regular mowing and maintenance program. As shown on Figure 3, current Site features include two abandoned buildings (in very poor condition), several berms, and a short section of abandoned railroad track.

Photographs of the Site and a drainage ditch area adjacent to the western boundary of the Site are shown in Appendix B, along with a map of the Site identifying the general area of the photograph. As shown in these photographs, the Site ground surface consists of gravel and/or grass covered areas with no trees and minimal undisturbed habitat. The portions of the Site that could potentially serve as ecological habitat are small in area, heavily disturbed because of the regular ground maintenance and previous removal activities, and unattractive to wildlife. There are no forested, brush land, wetland, or undisturbed field areas that would serve as valuable terrestrial habitat. As such, small mammal and bird use is expected to be minimal. Given the general absence of attractive habitat on the Site and the urban setting in general, the Site is not conducive to any appreciable use by resident wildlife and the risk assessment approach described in Section 5.7.2 (Task 7) reflects the limited potential exposure to terrestrial receptors at the Site.

As shown on the Site topographic map in Figure 3, the Site is relatively flat, with the limited elevation changes over the Site less than five feet and generally associated with the bermed areas. Rainfall runoff from much of the Site, particularly the northern tract, is controlled by berms in former Site operational areas. Outside of these bermed areas, runoff is generally to the east toward Somerset Drive. Runoff from the narrow area west of the bermed areas, on the western edge of the Site, is toward a shallow drainage ditch adjacent to the western perimeter of the Site (see Figure 3).

2.2.2.2 <u>Aquatic and/or Wetland Habitats</u>

The location and path of the drainage ditch west of the Site is shown on Figure 4. The ditch originates north of the Site and collects drainage from East Kelly AFB and other industrial properties (e.g., salvage yards, repair facilities, etc.) to the north. As such, the ditch contains a substantial amount of debris including trash, tires, rubble, and other urban refuse (see photographs in Appendix B). An evaluation of the ditch and downstream areas was performed as part of the Former Kelly Ecological Risk Assessment (CH2M-Hill, 2004). As noted therein, the ditch is typically dry and, further downstream, mostly concrete lined. The ditch drains to Sixmile Creek which originates approximately 2,000 feet south of the Site near the intersection of Wabash and Wagner Streets where other storm drains contribute to the cumulative flow (Figure 4). The Kelly evaluation noted the urban nature of Sixmile Creek at that point and characterized the creek as "an intermittent stream, located in a disturbed area, that meets acute water quality criteria specified in Table 1 of 30 TAC 307.6; lacks appreciable instream, edge, and riparian habitat, forage and shelter in or along the watercourse" (CH2M-Hill, 2004).

The ephemeral nature of the ditch directly to the west of the Site is illustrated in the April 2006 photographs in Appendix B. The occasional presence of standing water that accumulates after periods of rainfall is shown on the August 31, 2010 photographs in Appendix B. The primary vegetation found along the ditch is terrestrial plants and weeds. As noted previously, surface drainage and runoff from a limited portion of the Site may flow into the ditch depending on specific rainfall/runoff conditions. Although there is no evidence of soil erosion on-Site, COPCs entrained in soil particles may have migrated to the ditch. To evaluate potential impacts to the ditch, surface water samples will be collected during this investigation as described in Section 5.6.3. Since the ephemeral ditch does not contain consistent aquatic habitat, the surface water samples will be evaluated by comparing measured chemical concentrations against screening criteria for mammalian and avian receptors.

As described in Zone 4 Ecological Risk Assessment Report for the Former Kelly AFB (CH2M-Hill, 2004)(Section 2.5.3), National Wetland Inventory (NWI) maps indicated that the nearest wetland area in the vicinity is a portion of the Sixmile Creek concrete channel that has become overgrown with some opportunistic in-channel vegetation. This area is approximately 0.4 miles southeast of the Site.

2.2.2.3 <u>Plant and Animal Species</u>

In the vegetated areas of the Site, the single dominant vegetation type is grassland, with most plants not exceeding 4 to 6 inches in height because of mowing. The grassland community is composed of a limited variety of native grasses and other opportunistic herbaceous groundcover species that are typical to this area of Texas. A variety of small shrubs and trees are present on the fence line, most notable are new growth mesquite trees.

During previous Site visits, no terrestrial animals have been observed on-site, although there was physical evidence of canines using the Site and anecdotal evidence that wild dogs roam the area. Birds, such as the American robin, mockingbird, and dove, were observed at the Site on various visits. Since there is some vegetative cover at the Site around the fence line, it is possible that small ranging mammals and some avian species might inhabit and/or forage at the Site although it is unlikely that the Site serves as a significant ecological resource. In addition, regular ground maintenance makes the Site unsuitable for widespread foraging, and nesting, and this is supported by the lack of observable wildlife during Site visits. These visits have, however, occurred during the day, which typically would reduce the chances of seeing small ranging mammals and other wildlife since many are less active during the day.

2.2.2.4 <u>Threatened and Endangered Species</u>

There are no known occurrences of federal or state listed threatened or endangered plant or animal species, or natural communities within the Site boundaries, and none have been observed at the Site during numerous visits. Given the general absence of attractive habitat on the Site and the urban setting in general, it is unlikely that the Site is used by resident wildlife, including common, threatened, or endangered species. According to the Zone 4 Ecological Risk Assessment Report for the Former Kelly AFB (CH2M-Hill, 2004), there are no known occurrences of federal or state listed threatened, or endangered plant or animal species in the vicinity. A letter from the US Fish and Wildlife Service supporting this conclusion for the Kelly AFB site is provided in Appendix C.

2.3 HYDROGEOLOGIC FRAMEWORK

2.3.1 Regional Geologic/Hydrogeologic Setting

The San Antonio area is located within two physiographic provinces, the Edwards Plateau to the northwest and the Gulf Coastal Plain to the southeast (USGS, 1995). These two provinces are divided by the Balcones Fault Zone, which extends south from McLennan County through the northern portion of Bexar County, and then to the west to Val Verde County. The Edwards Plateau located northwest of the fault zone, is characterized by resistant limestone and dolomite units of the Lower Cretaceous that create a high plateau northwest of San Antonio. East of the fault zone the sediments to the east consist of non-resistant chalk and calcareous clays. The area within the fault zone is known as the Balcones Escarpment, which is characterized by an escarpment feature along the fault line as a result of the difference in resistance to erosion between the lithologic units (Abbott and Woodruff, 1986). The Gulf Coastal Plain southeast of the Balcones Fault Zone is characterized by low to moderate relief and is underlain by sands and clays of Tertiary age (USGS, 1995). The Site is located along the southeast margin of the Balcones Escarpment within the Gulf Coast Plains.

The Site lies within the Quaternary-aged fluviatile terrace deposits (Figure 5). These deposits consist of gravel, silt, sand, clay, and organic material (Barnes, 1983), and are generally less than 50 feet thick (Sellards, 1919). The terrace deposits are underlain by clays of the Navarro Group which extend approximately 450 feet below the surface. The Navarro Shale is underlain by the Taylor Marl (approximately 450 feet thick), followed by the Upper Cretaceous formations including the Anacacho Limestone, Austin Chalk, and the Eagle Ford Shale (approximately 400 feet thick); and Buda Limestone and Del Rio Clay (also known as the Grayson Shale), which together are approximately 140 feet thick (Sellards, 1919, and Arnow, 1959). The Edwards

Aquifer underlies these formations at a depth of approximately 1,500 ft in the vicinity of the Site (CH2M-Hill, 2003).

The shallow formations above the Edwards Aquifer are not considered major or minor aquifers of Texas (Ashworth & Hopkins, 1995). The Navarro Group and the Taylor Marl, consisting of the top 900 feet in the vicinity of the Site, are not known to yield water to wells in Bexar County (Arnow, 1959). The shallowest formation known to supply sufficient water for domestic or livestock use in the San Antonio region is the Austin Chalk. Wells that have higher water yields in the Austin Chalk are predominantly found in northern Bexar County, distant from the Site, and may be hydraulically connected with the Edwards Aquifer by faults within the Balcones Fault Zone (Arnow, 1959). The underlying Eagle Ford Shale is not known to yield water to wells, and the Buda Limestone only yields small quantities of water for domestic or livestock use near the outcrop. The Del Rio Clay (Grayson Shale) also does not yield water to wells completed in Bexar County (Arnow, 1959).

The major aquifer in the region is the Edwards Aquifer, which covers approximately 4,350 square miles and is designated a “sole source” water supply for the City of San Antonio. The aquifer is characterized as highly permeable as a result of fracturing and dissolution of the limestone creating permeable solution zones and channels. The Edwards Aquifer is primarily recharged by surface water infiltration provided by the streams throughout the Edwards Plateau (USGS, 1995).

An evaluation of the stratigraphy, faulting, water-bearing units, and potential for hydraulic communication between the shallow terrace deposit groundwater zone and the underlying Edwards Aquifer was performed in 2002 by the Bureau of Economic Geology (Hovorka, et. al. 2002). This study evaluated the hydraulic gradient between the shallow groundwater zone and the Edwards Aquifer and assessed the potential for faults and water wells to serve as potential pathways between the two units. A literature survey performed for the evaluation indicated that the faults and fractures are unlikely to have high transmissivity and a follow up assessment (Miller, 2003) agreed that “diffusion alone would require thousands of years for contaminants to reach the Edwards Aquifer and that faults or fractures are unlikely pathways…”. The two reports concluded that during normal or high water levels in the Edwards Aquifer, a sufficient hydraulic gradient does not exist to allow communication between the upper zone and the Edwards Aquifer, and, during low water level periods in the Edwards Aquifer the upper zone is likely not present.

An extensive water well survey was conducted in the vicinity of the Site as part of East Kelly AFB investigations (AFBCA and AFCEE, 2001). This survey was conducted in several phases from 1988 until 2001, and included a records search, a field survey and water well sample collection/analyses. The survey identified only two shallow aquifer water wells within approximately 2,000 feet of the R&H Oil/Tropicana Energy Site. Both of those wells were identified as having been plugged. Given the age and character of the neighborhoods surrounding the Site, and the long-time presence of a municipal water supply for the area, it is unlikely that new domestic wells have been constructed in the shallow groundwater-bearing zone in the Site vicinity since that survey was performed. Representatives of the San Antonio Water System (SAWS, 2010) indicated that they were not aware of any recent water well permitting/drilling activity in the area.

2.3.2 Site Geology/Hydrogeology

Geologic logs from soil and monitoring wells borings provided in the previous investigations (Raba-Kistner, 1991; ERM, 2004) were reviewed to evaluate the shallow geology at the Site. The soils described in the previous investigations are consistent with the published descriptions of the terrace deposits and Navarro Shale. For the purposes of this Work Plan, the Site stratigraphy from the ground surface to a total depth of approximately 50 feet is separated into three general units: (1) Upper Clay; (2) Basal Terrace Deposit Sands and Gravels; and (3) Lower Clay Unit/Navarro Shale. Descriptions of the lithologic units are discussed below:

- Upper Clay – This unit is characterized by fill, clay and silty clay intervals with calcium carbonate nodules from ground surface to about 12 to 22 feet below grade. The clays and silty clays are gray to tan in color, and frequently contain caliche nodules.

- Basal Terrace Deposit Sands and Gravels – The Upper Clay Unit grades into sand and gravel intervals with clay interbeds within the sands and gravels ranging in thickness from less than one foot thick to over five feet thick. At monitoring well MW-4, no clay interbeds were observed within the sands and gravels, which were about 24 feet thick (Raba-Kistner, 1991). The sands are characterized as tan and gray in color, and contain some clay and gravel. The gravels are characterized as tan and gray, with varying amounts of clay and sand, and frequently contain cobbles and chert fragments. The lower portions of the terrace deposit overlying the Navarro Shale are generally sandy or clayey gravels. The thickness of this unit ranges from 24 feet at monitoring well MW-2 to 33 feet at monitoring well MW-6 (based on boring logs from Raba-Kistner, 1991).

- Lower Clay Unit/Navarro Shale – The Lower Clay Unit was described as a gray and reddish-brown clay interval, with common limestone fragments and noted as dry in the boring logs (Raba-Kistner, 1991). Due to the thickness of this unit, the base of the Navarro Shale (approximately 450 feet bgs) was not encountered during investigations at the Site.

The Basal Terrace Deposit Sands and Gravels serve as the uppermost groundwater bearing zone (GWBZ) at the Site. Depth to water in this unit is reportedly approximately 10 to 19 feet below ground surface (TNRCC, 2001; ERM, 2004). Based on groundwater potentiometric levels gauged at the Site, the apparent direction of groundwater flow in this unit is toward the east-southeast at an approximate gradient of 0.001 (ERM, 2004).

The Lower Clay Unit serves as the lower confining unit for the uppermost water-bearing unit, and restricts any deeper vertical migration of groundwater at the Site. The Navarro Group and other Upper Cretaceous unit clays, limestone, and shale serve as a regional aquitard separating the terrace deposit from the deeper Edwards Aquifer as described above.

2.4 SITE HISTORY

2.4.1 <u>Ownership and Operational History</u>

An understanding of the Site's operating history was developed through review of the R&H Oil Company Site Screening Report (TNRCC, 2000) and the HRS Documentation Record (TNRCC, 2001). A summary of the history is provided on Table 1 and is discussed below.

The specific date when industrial operations started at the Site is not known. An October 1929 aerial photograph (EPA, 2003) shows the Site area as vacant land. According to TNRCC, 2000, an operating refinery is indicated in aerial photographs from as early as 1938, with storage tanks visible on both the northern and southern tracts. A February 1939 photograph (EPA, 2003) shows substantial industrial operations in both the northern and southern tracts.

It appears that the original refinery at the Site operated on both the northern and southern tracts. According to TNRCC, 2001, Monarch Refining Company/Wing Corporation operated on certain of the northern tract lots and on the southern tract lots from 1950 to 1974. Flint Ink Corporation operated a refinery on certain other northern tract lots. As listed in Table 1, later Site operations included oil recycling and waste oil refining activities on the northern tract and a petroleum products distribution facility, and then a gasoline blending operation on the southern tract. Waste oil recycling activities on the northern tract, and the fuel/gasoline blending operations on the southern tract, ceased in approximately the late 1980's or early 1990's and the Site remained inactive (TNRCC, 2001).

Operational areas at the Site varied by the specific operations being performed at a given time. The northern part of the Site was generally reported to contain process areas/buildings, a warehouse, an office, an API separator, pump houses, tank batteries, and a railroad loading platform (TNRCC 2000). The southern part of the Site was reported to contain tank batteries and drum storage areas (TNRCC, 2001).

2.4.2 Regulatory and Investigation History

As listed on Table 1, the regulatory and investigation history of the Site includes site inspections, spills, and associated investigations in the 1980s and early 1990s. The most significant of these appears to have been the release of approximately 8,000 gallons of natural gasoline during off loading of a tanker truck on April 18-19, 1990. This release occurred into, and then outside of, an on-site bermed area on the southern tract, reportedly spreading over a 700 square yard area (Raba Kistner, 1991). Following initial response and recovery operations (approximately 7,800 gallons were reportedly recovered), eight soil borings and six monitoring wells were installed and sampled in the southern tract. These six monitoring wells (MW-1 through MW-6) are shown on Figure 2 (all wells except MW-5 have been located at the Site). Petroleum hydrocarbons were reportedly encountered at all eight soil boring locations, with Light Non-Aqueous Phase Liquid (LNAPL) observed in several soil cores. Records from the investigation do not indicate that LNAPL accumulated within the monitoring wells (Raba Kistner, 1991).

The first overall Site assessment, rather than specific spill/release incidents, was initiated with concurrent removal assessments of the R&H Oil Company, Inc. ("R&H Site") and Tropicana Energy Company, Inc. ("Tropicana Site") sites (E&E, 1998a; and E&E, 1998b; respectively) in

April 1998. Assessment activities included an inventory of tank equipment, tankage, and drums; and collection of oil, waste, sludge, soil, groundwater, and building (asbestos) samples. Soil sample locations for these assessments are shown on Figure 6. Based on the findings of the removal assessments, removal actions were performed during the period from August to October, 2001 (Weston, 2002a; and Weston, 2002b).

Removal actions at the R&H Site included removal of asbestos containing materials (ACM) from on-site containers, equipment, piping, and within buildings; removal of materials from within on-site containers, equipment, and piping; removal (demolition) of on-site containers, equipment, piping and other items, and removal of impacted soils. The following materials were removed from the R&H Site (Weston, 2002a):

- 52,906 gallons of oil with a bottoms sediment and water content greater than 30% for off-site disposal.
- 26,701 gallons of wastewater for off-site disposal.
- 1,396 cubic yards of contaminated soil were removed for off-site disposal.
- 30 cubic yards of asbestos containing material (ACM) for off-site disposal.
- 120 cubic yards of oily debris for off-site disposal.
- 443 tons of metal for sale as scrap.

Removal actions at the Tropicana Site included removal of materials from within on-site containers, equipment, and piping, including an underground storage tank; removal (demolition) of on-site containers and equipment, piping and other items; and removal of impacted soils. The following materials were removed from the Tropicana Site (Weston, 2002b):

- 1,626 gallons of benzene-contaminated wastewater for off-site disposal.
- 4,715 gallons of wastewater for off-site disposal.
- 96 cubic yards of contaminated soil for off-site disposal.
- 144 tons of metal for sale as scrap.

In December 2003, the Texas Department of Health (TDH) and the Agency for Toxic Substances and Disease Registry (ATSDR) conducted a PHA for the Site (ATSDR, 2003). This assessment evaluated available Site information and identified potential exposure pathways through which people might come into contact with Site COPCs. The pathways evaluated included possible contact with Site COPCs in surface water, air, soil, groundwater, and soil gas. Based on that evaluation, the PHA concluded that "at present the R&H Oil Company/Tropicana Energy Company site poses no apparent public health hazard" (ATSDR, 2003).

In 2004, some members of the R&H Oil Company Site Group voluntarily conducted a preliminary investigation at the Site to gain a better understanding of the current Site conditions. This investigation, the undertaking and scope of which were not approved by EPA in advance, involved collection of soil samples from seven on-site and four off-site soil borings (Figure 6). Six of the on-site borings and all four of the off-site soil borings were converted to temporary monitoring wells for the collection of groundwater samples. LNAPL samples were also collected from one temporary on-site monitoring well and two previously existing monitoring wells (MW-3 and MW-6 installed as part of the 1991 Raba Kistner investigation described above). The investigation results indicated that Site soils and groundwater were affected by petroleum hydrocarbons, including benzene, toluene, ethylbenzene and xylene (BTEX) constituents, but the off-site impacts appeared very limited (ERM, 2004). The data collected from this investigation have not been validated or formally approved by EPA.

A passive soil gas survey was performed at the Site during September 2008 by an EPA contractor (SAIC, 2008). This survey involved the placement of passive soil gas collection vials in the shallow subsurface (depth range of two to three feet) for a 15-day sampling period. After completion of the sampling period, the sampling devices were retrieved and the samplers analyzed for volatile organic compounds (VOCs). The investigation concluded that COPC concentrations were "mainly located in the center of the site" (SAIC, 2008).

3.0 INITIAL EVALUATION

3.1 EXISTING DATA

The first step in the approach to scoping the investigation program for filling the identified data needs (see Section 3.5) is the review of existing data. Existing data were used to develop the preliminary Conceptual Site Model (CSM) and identify data needs. Existing soil and groundwater data from the Site and nearby locations (i.e., East Kelly AFB) were compiled into tables for evaluation (see Tables 2 through 8). These data are used for scoping purposes and will not be used in the risk assessment or in the evaluation of potential remedial alternatives in the FS.

The existing datasets were used to develop preliminary projections of number of samples and sample locations for the RI/FS. Existing dataset characteristics (e.g., mean, standard deviation, distribution type) and threshold values (e.g., reference values) for selected representative compounds in soil were input into Visual Sample Plan (VSP) software (Version 4.0) as a preliminary evaluation of the potential number of soil samples needed for the RI. The VSP projection was based on the objective of identifying the number of samples needed to demonstrate that a sample population is below a specific reference value. For metals, such as arsenic, chromium, and lead, this evaluation projected approximately 11 to 13 samples. For xylenes, the projection was 29 soil samples. For other compounds, most notably benzene and benzo(a)pyrene, where Site concentrations significantly exceed reference values, the VSP projection was several thousand samples, thereby illustrating the limitations of this approach for datasets that significantly exceed threshold values. Additional details regarding VSP procedures and results are described in the Scope of Work attached to the Settlement Agreement and are included as Appendix D of this document.

Selected groundwater data from ongoing groundwater monitoring activities associated with the former East Kelly AFB were also evaluated (Table 9). The monitoring wells are located within approximately one-half mile of the Site (see Figure 7 for selected monitoring well locations) and have been sampled on an annual basis since at least 2001. Groundwater samples collected between 2001 and 2006 were analyzed for BTEX in addition to chlorinated ethenes (ongoing sampling of these wells for chlorinated ethenes is continuing but BTEX analyses have apparently not been performed since 2006). Occasional BTEX detections were reported in these wells (none in 2005) and all reported concentrations have been less than 0.001 mg/L (as a point of reference, the TCEQ groundwater ingestion protective concentration level (PCL) for benzene, the most stringently regulated component of the BTEX compounds, is 0.005 mg/L). These data and the groundwater data for off-site temporary wells (see Table 7) sampled in 2004 suggest that the lateral extent of BTEX-containing groundwater may be limited to the near vicinity of the Site.

3.2 POTENTIAL SOURCE AREAS AND CHEMICALS OF POTENTIAL CONCERN

Petroleum hydrocarbons are the primary COPCs present at the Site. As described previously, potential historical source areas (PHSAs) for these COPCs include former processing buildings, tank batteries, a railroad loading platform, an oil/water separator and drum storage areas. Notwithstanding these PHSAs, it is recognized that the locations at which COPCs were stored, generated, and handled have likely changed to some degree during the approximately 70 years since refinery operations began at the Site and since the years that waste oil recycling and fuel blending activities occurred at the Site. During the performance of preliminary investigation activities at the Site in 2004 (ERM, 2004), petroleum hydrocarbon odors, staining, or LNAPL were observed in most of the seven borings drilled on the Site. LNAPL has been reported at several locations on-site (MW-3, MW-5, MW-6, and ERM-SB-8) (see Figure 6 for locations). The lateral extent of LNAPL has not been defined, although the LNAPL thicknesses reported in Site monitoring wells were less than 1.0 foot when last measured in 2004 (ERM, 2004). Although not observed in previous Site monitoring wells, dense non-aqueous phase liquid (DNAPL) has been encountered at other refinery sites. The possible presence of DNAPL will be evaluated as part of Site characterization activities.

As noted previously, the former East Kelly AFB west of the Site is the source of a large regional plume of chlorinated ethenes in the uppermost water-bearing unit. The aforementioned automobile repair and service station facilities north and west of the Site may be potential sources of petroleum hydrocarbons to the uppermost water-bearing unit in the vicinity of the Site.

3.3 CONCEPTUAL SITE MODEL

The CSM presents the current understanding of the type and occurrence of potential COPC sources and possible exposure pathways associated with the Site. Consistent with EPA RI/FS Guidance (EPA, 1988), the CSM was developed on the basis of existing Site data. The hypotheses presented in the CSM will be tested, refined, and modified as necessary as data are collected during the RI.

Based on an evaluation of the potentially complete pathways, and an analysis of the information needed to assess the completeness of these pathways, data needs were identified to satisfy the objectives of the RI/FS and to establish the objectives set forth in this Work Plan as described below.

3.3.1 Human Health

Figure 8 identifies potential human health exposure pathways at the Site and describes the processes or mechanisms by which human receptors may reasonably come into contact with Site-related constituents. Figure 9 presents a similar analysis for potential ecological receptors. Exposure pathways are dependent on current and future land use. An exposure pathway is defined by four elements (EPA, 1989):

- A source material and mechanism of constituent release to the environment;
- An environmental migration or transport media (e.g., soil) for the released constituents;
- A point of contact with the media of interest; and
- An exposure route (e.g., ingestion) at the point of contact.

An exposure pathway is considered "complete" if all four elements are present.

Complete human health exposure pathways are indicated with a bold line and check in the receptor column of Figure 8. Although a pathway may be preliminarily identified as complete, additional data are often needed to evaluate the significance of the complete pathway. The CSM also identifies potentially complete pathways with a dashed line and check in the potential receptors column of Figure 8. Information related to potentially complete exposure pathways will be used to identify data gaps and help guide the data collection effort, ultimately ensuring that sufficient data are collected to facilitate quantitative evaluation in the human health risk assessment.

As shown in Figure 8, direct contact and ingestion of soil by potential on-site receptors is considered a complete and potentially significant pathway. Additional data are needed from the RI to evaluate the significance of this pathway. Pathways associated with inhalation of indoor/ambient air by potential on-site receptors as a result of COPC volatilization from soil or dispersion from fugitive dust are identified as potentially complete pathways meaning that data are needed from the RI to evaluate whether these pathways are complete and/or significant. Potential on-site or off-site receptor inhalation of COPCs due to volatilization from LNAPL and/or groundwater is also considered a potentially complete pathway requiring RI data for further evaluation. Given the nature of the potential off-site receptor exposure via this pathway (relative to the restricted nature of on-site pathways as a result of perimeter Site fencing), the evaluation of the off-site component of this pathway will be a higher priority than the on-site pathways, and thus an initial RI data collection activity. If complete pathways are identified during the RI (i.e., concentrations exceed pathway-based screening criteria at a receptor), then risks will be calculated for the potentially exposed population during the risk assessment.

3.3.2 Ecological

Complete ecological pathways are designated with a solid box on Figure 9 while potentially complete pathways on this figure are indicated with a solid circle. Complete ecological exposure pathways are related to direct contact and ingestion of soil, and ingestion of food. Soil data collected during the RI will be used to evaluate the significance of these pathways in a Screening-Level Ecological Risk Assessment (SLERA).

Potential ecological pathways associated with on-site ponded water and the drainage ditch west of the Site were initially considered complete and potentially complete (respectively) for the purposes of the Scope of Work attached to the Settlement Agreement. After further discussion and evaluation in preparation of this Work Plan, the on-site ponded water pathway is considered incomplete as shown on Figure 9. Ponded water at the Site is ephemeral in nature, being present in low areas for only a short period after significant rainfall events. As described in Section 2.2, a detailed evaluation of the drainage ditch as part of investigations at the East Kelly AFB concluded that both the ditch and downstream creek section were intermittent and lacked consistent aquatic habitat; however, the ditch surface water pathway is considered complete for potential mammalian and avian receptors.

As data are collected during the RI, the CSM presented in Figures 8 and 9 will be updated and refined.

3.4 DATA NEEDS

Based on an evaluation of the potentially complete pathways identified in Figures 8 and 9, and an analysis of the information needed to assess the completeness of these pathways, the data needs listed in Table 10 were developed. This table illustrates the data needs evaluation process by: (1) noting the conceptual model potential exposure routes that were judged to be potentially complete or complete and potentially significant; (2) identifying the specific data needs for determining whether the identified pathway is complete and significant; (3) listing the existing data that were reviewed as part of an initial evaluation; and (4) describing the RI activities to be performed to fill the identified data need. As described in Table 10, the identified data needs are associated with five general categories: (1) Site soils data needed to evaluate the direct contact, ingestion or inhalation potential exposure pathways from soil to on-site and off-site receptors, (2) Site NAPL and groundwater data needed to evaluate the inhalation potential exposure pathways from these media to on-site receptors; (3) Site soil gas and subslab vapor data needed to evaluate potential on-site vapor intrusion exposure pathways; (4) off-site drainage ditch surface water data to evaluate potential mammalian and avian ecological exposures; and (5) off-site groundwater data needed to evaluate the inhalation potential exposure pathway from groundwater to off-site receptors. As discussed above, the off-site groundwater data need is proposed as the initial data collection activity because of the relatively higher priority of the off-site pathway and because these data would provide an “outside-in” approach toward quickly establishing the extent of COPCs in the Site vicinity.

Several FS data needs are also included in Table 10; however, potential remedial alternatives to be evaluated in the FS will not be limited to those associated with specific data needs listed in Table 10. The FS data needs listed in Table 10 represent those for which specific information should be obtained as part of the RI. If additional FS data needs are identified as the interactive RI/FS process proceeds, appropriate programs to fill these needs will be developed. The development and evaluation of remedial alternatives will be performed as specified in the RI/FS guidance (EPA, 1988). First, the risk assessment findings will be used to develop remedial action objectives. General response actions will be developed to address these objectives, and then technology/alternatives associated with those response actions will be screened.

As indicated in Table 10, the currently identified FS data needs consist of: (1) data related to soil geotechnical properties (needed to evaluate potential remedial action alternatives involving capping, using pavement, turf or other cover); (2) data related to the occurrence of natural attenuation; and (3) data related to LNAPL properties and LNAPL recoverability (needed to evaluate potential remedial action alternatives involving LNAPL recovery).

4.0 WORK PLAN RATIONALE

This section addresses the data requirements for the human health and ecological risk assessments and the remedial alternatives evaluation, and describes how the proposed remedial investigation will satisfy these data needs.

4.1 DATA QUALITY OBJECTIVES

Data quality objectives (DQOs) are based on the proposed end uses of data generated from sampling and analytical activities. DQOs are qualitative and quantitative statements that outline the decision-making process and specify the data required.

DQOs are developed through a seven-step process (EPA, 2006):

(1) State the problem;
(2) Identify the goals of the study;
(3) Identify the information inputs;
(4) Define the boundaries of the study;
(5) Develop the analytical approach;
(6) Specify performance or acceptance criteria; and
(7) Develop the plan for obtaining data.

As noted in Section 1.0, the overall objective to be addressed by the RI/FS is to evaluate the nature and extent of COPCs at and from the Site, assess the risk from these COPCs to human health and the environment, and evaluate potential remedial alternatives. More specific problems and subsequent steps in the DQO process vary for each of the indeterminant or complete and potentially significant exposure routes identified in the CSM and used to develop the data needs in Table 10. The seven DQO steps were completed as part of the Quality Assurance Project Plan (QAPP) development process and are addressed in Section 2.4.1 of the QAPP (PBW, 2010c).

4.2 WORK PLAN APPROACH

The general technical approach for the RI/FS at the Site is based on the following overarching components:

- Use of Existing Data. Given the amount of existing information, and consistent with the Settlement Agreement requirements (SOW Paragraph 20.b, "Evaluate Existing Information"), the RI/FS Work Plan relies heavily on the use of existing data. These existing data are used as the basis for development of the CSM and data needs evaluation process described previously. The existing data were used for scoping purposes and will not be used in the risk assessment or in the evaluation of potential remedial alternatives.

- Focus on Potential Receptors. Notwithstanding the identification of COPCs and PHSAs as described previously, the RI/FS focuses on potential receptors and an evaluation of the risks associated with the potential exposure pathways identified in the CSM through a receptor-based investigation program. As the investigation proceeds, the CSM is updated to incorporate the information obtained.

- Consideration of Site End Use Objectives - In addition to the aforementioned goals to characterize the nature and extent of COPCs and evaluate potential risks, the RI/FS also considers the desired end use for the Site, both in terms of land use, and potential site development issues, particularly to the extent that the Site remedy supports potential future Site uses.

- Recognition of Potential Contributions from Natural Process to Site Remediation – Existing data suggest several natural processes are worthy of consideration as the RI/FS proceeds and potential remedial alternatives are developed. Specifically, attenuation of petroleum hydrocarbons in groundwater will be assessed to determine the applicability of monitored natural attenuation (MNA) or plume stability monitoring as a component of the final site remedy (EPA, 1999)(EPA, 2004). As such, the RI/FS includes the collection of data necessary to evaluate natural processes at the Site.

These overarching components of the RI/FS Work Plan approach have been used as a foundation for the development of the detailed RI/FS Work Plan tasks described in Section 5.0.

5.0 RI/FS TASKS

As noted in Section 1.0, the objective of the RI/FS Work Plan is to document the decisions and evaluations made during the RI/FS scoping process and present a summary of the work to be performed during the RI/FS. The Work Plan also presents the initial evaluation of existing Site data and background information, and describes the project management team and schedule. The RI and FS are interactive and will be conducted concurrently, to the extent practicable, in a manner that allows information and data collected during the RI to influence the development of remedial alternatives during the FS. This interactive relationship will in turn affect additional information and data needs and the scope of any necessary treatability studies and risk assessments.

The following tasks are designed to meet the objectives of the RI/FS.

5.1 TASK 1: PROJECT PLANNING (SCOPING)

The purpose of Task 1, Project Planning, is to determine how the RI/FS will be managed and controlled. A project scoping meeting is a key part of this task. The scoping phase meeting for the Site was held at the EPA Region VI offices in Dallas, Texas on March 24, 2010. The topics discussed, documents exchanged and action items taken from that meeting are documented in the meeting notes included in Appendix A. The meeting discussions have been incorporated in the development of this RI/FS WP (Task 2, below).

5.2 TASK 2: REMEDIAL INVESTIGATION/FEASIBILITY STUDY (RI/FS) WORK PLAN

The RI/FS WP (this document) is developed in conjunction with the RI/FS Sampling and Analysis Plan (SAP) and the Health and Safety Plan (HASP). The following specific elements are included in this RI/FS WP in accordance with the Settlement Agreement (SOW Paragraphs 21 through 24) and EPA Guidance (EPA, 1988):

- A comprehensive description of the work to be performed, the methodologies to be utilized, and a corresponding schedule for completion;
- Rationale for performing the required activities;

- A statement of the problem(s) and potential problem(s) posed by the Site and the objectives of the RI/FS;

- A site background summary, which includes the geographic location of the Site, and to the extent possible, a description of the Site's physiography, hydrology, geology, and demographics; the Site's ecological, cultural, and natural resource features; a synopsis of the Site history and a description of previous responses that have been conducted at the Site by local, state, federal, or private parties;

- A summary of the existing data in terms of physical and chemical characteristics of the COPCs identified, and their distribution among the environmental media at the Site;

- A description of the site management strategy developed during scoping;

- A preliminary Conceptual Site Model; and

- A detailed description of the tasks to be performed, information needed for each task and information to be produced during and at the conclusion of each task, and a description of the work products and deliverables to be submitted to the EPA.

5.3 TASK 3: RI/FS SAMPLING AND ANALYSIS PLAN

The SAP provides a mechanism for planning field activities and consists of an RI/FS Field Sampling Plan (FSP) and Quality Assurance Project Plan (QAPP) as follows:

- <u>RI/FS Field Sampling Plan</u> – The RI/FS FSP (PBW, 2010b) defines in detail the sampling and data gathering methods that will be used for the project. It includes descriptions of sampling objectives, sample rationale, locations and frequency, sampling equipment and procedures (including standard operating procedures (SOPs)), and sample handling and analysis.

- <u>RI/FS Quality Assurance Project Plan</u> – The RI/FS QAPP (PBW, 2010c) describes the project objectives and organization, functional activities, and quality assurance and quality control (QA/QC) protocols that will be used to achieve the desired DQOs. The RI/FS QAPP also addresses sampling procedures, sample custody, analytical procedures, data reduction, data validation, data reporting, and personnel qualifications (EPA, 2001 and EPA, 2002a).

The RI/FS SAP, including the FSP and QAPP, addressing the above requirements is submitted to EPA concurrent with this RI/FS WP. The FSP and QAPP provide for the addition of plan addenda as the need for additional field sampling or quality assurance procedures are identified during the course of the RI/FS.

5.4 TASK 4: RI/FS HEALTH AND SAFETY PLAN

An RI/FS Site HASP must be in place prior to any on-site activities. The HASP describes the safety and health protocols for PBW personnel and subcontractors during RI/FS field activities. The plan assigns personnel responsibilities, prescribes mandatory safety procedures, and establishes personal protective equipment requirements for the various field investigation tasks. The HASP provides for the addition of plan addenda as additional sampling or health and safety activities are identified during the course of the RI/FS. The HASP addressing the above items and pertinent Occupational Safety and Health Administration (OSHA) and EPA requirements is being submitted concurrently with the RI/FS Work Plan.

5.5 TASK 5: COMMUNITY RELATIONS PLAN

As described in Paragraph 30 of the SOW, development and implementation of community relations activities, including conducting community interviews and developing a community relations plan, are the responsibilities of EPA. EPA prepared an initial Community Involvement Plan (CIP) in July 2008 (EPA, 2008). As indicated therein, EPA will revise the CIP as community concern warrants or at least every three years until the Site is closed. The extent of the Respondents' involvement in community relations activities will be determined by EPA. During the project scoping meeting EPA indicated that it would be updating the CIP in the near future (see Appendix A).

5.6 TASK 6: SITE CHARACTERIZATION

This task involves the implementation of the RI/FS WP as detailed in the SAP, including the FSP and QAPP, in accordance with the HASP. The overall objective of the Site's characterization is to identify areas of the Site that may pose a threat to human health or the environment. This objective will be accomplished by completing the CSM which characterizes the physical properties of the Site, surface and subsurface pathways of migration, sources, nature, and extent of COPCs, and ultimately the fate and transport of COPCs at the Site.

The implementation of the Final RI/FS WP and SAP will be conducted during this phase of the RI/FS. Per Paragraph 48.b of the Settlement Agreement, EPA will be verbally notified at least fifteen (15) calendar days prior to commencement of significant field events at the Site. Since the RI/FS activities are iterative, it may be necessary to supplement the work specified in the WP.

The ultimate deliverable for Site characterization is the RI Report (Task 9).

In order to assess the extent of COPCs in Site soils and groundwater as part of Site characterization activities, an extent evaluation value was established for each COPC in soil and groundwater at the Site. It is important to note that these extent evaluation values will be used only to assess the extent of COPCs in Site soils and groundwater and will not be used as screening values for risk assessment purposes (and thus will not be used to eliminate a COPC from further evaluation in a risk assessment). For soil, the extent evaluation values are the lower of EPA's Regional Screening Levels (RSLs), and TCEQ PCLs for soil contact (including ingestion, dermal contact and/or inhalation) by residential receptors (Table 11). These extent evaluation values will be updated to reflect currently available values at the time of evaluation for all compounds detected and may be revised to account for background concentrations if appropriate (based on the presence of background concentrations of a specific COPC in soil). For groundwater, the extent evaluation values are the lower of EPA's generic values for evaluating the vapor intrusion risk from groundwater, and the TCEQ residential PCLs for groundwater ingestion (Table 12). These extent evaluation values will also be updated to reflect currently available values at the time of evaluation for all compounds detected and may also be revised to account for background concentrations if appropriate (based on the presence of background concentrations of a specific COPC in groundwater). It is emphasized that the extent evaluation values (and the possible consideration of background concentrations of a COPC therein) will be used only for assessing the extent of COPCs in soil and groundwater and will **not** be used for screening COPCs in a risk assessment. It should also be noted that although the extent evaluation values will be used to evaluate the lateral extent of a COPC, COPC concentrations that exceed extent evaluation comparison values may not necessarily be indicative of adverse effects.

In light of the commercial/industrial nature of the Site, its urban setting, and general absence of attractive habitat for resident wildlife, ecological screening values were not used for development of extent evaluation comparison values. However, ecological screening values, such as TCEQ ecological benchmarks (TCEQ, 2006), will be used to evaluate risks to potential ecological receptors in the ecological risk assessment as described in Section 5.7. Ecological screening values to be used for this purpose for soil are listed in Table 13.

A local soil background study was performed in conjunction with the aforementioned extensive investigation activities performed at nearby East Kelly AFB. This study (SAALC, 1999) established local background concentrations of a number of metals in soil using a site-specific sampling and statistical approach. Specifically, the Kelly study evaluated background levels in three soil types: (1) black clay (generally considered surface soils to a depth of approximately seven feet below grade); (2) brown clay (underlying soils to the base of the uppermost water-bearing unit); and (3) Navarro Shale (the lower confining unit). For the purposes of this RI/FS, the black clay values will be considered potentially representative of Site background and these are the "Kelly AFB" background values included in Table 11. Texas-specific background values may also be considered as potential Site background concentrations. Additional site-specific background soil sampling may also be performed, if warranted, during the RI/FS as described in Section 5.6.2 below. Again, these background values will only potentially be considered for assessing the extent of COPCs and will **not** be used to screen any COPCs in a risk assessment.

5.6.1 Subtask 6.1: Off-site Groundwater Investigation

Based on the CSM analysis described previously, five permanent off-site groundwater monitoring wells will be installed and sampled. The purpose of these wells is to evaluate the off-site groundwater pathway and delineate the off-site lateral extent of the groundwater COPCs from the Site in the uppermost water-bearing unit. As shown on Figure 10, these wells include the following:

- One monitoring well (MW-11) on Brunswick Boulevard, near the intersection with Somerset Road;
- Two monitoring wells (MW-9 and MW-10) along Fitch Street east of Somerset Road; and
- Two monitoring wells (MW-7 and MW-8) along Milvid Ave. east of Somerset Road.

The soil borings for these monitoring wells will be drilled using hollow-stem augers to the top of the Navarro Shale (approximately 30-50 ft below ground surface). Borings will be sampled continuously for lithologic purposes and for field headspace measurements using an organic vapor meter (OVM). The monitoring wells will be developed by bailing, surging and/or pumping. Following development and a sufficient recovery time, the wells will be gauged for water levels and the possible presence of LNAPL. The wells will then be purged and sampled using low flow sampling methods. Temperature, specific conductance, pH, turbidity, dissolved oxygen (DO) and oxidation/reduction potential (ORP) will be measured in a flow cell during purging and sampling. Detailed well installation, development, and sampling procedures are provided in the FSP.

Based on historical knowledge of Site activities and existing data, groundwater samples from the off-site groundwater monitoring wells will be analyzed for the VOCs, semivolatile organic compounds (SVOCs), total petroleum hydrocarbons (TPH), and metals indicated on Table 12. Groundwater samples from off-site monitoring wells will also be analyzed for nitrate, nitrite, sulfate, and ferrous iron (field measurement) as part of the evaluation of plume behavior and natural attenuation of Site COPCs. Laboratory and quality assurance/quality control procedures are specified in the FSP and QAPP. As part of the RI, groundwater data will be compared to the evaluation comparison values listed in Table 12 to assess the extent of these COPCs. As noted previously, the extent evaluation comparison values in Table 12 will be updated to reflect current available values at the time of evaluation for all compounds detected and may be revised to account for background concentrations if appropriate due to the presence of background concentrations of a specific COPC in groundwater. The groundwater data will also be used in the human health risk assessment to evaluate the completeness and significance of the identified potential groundwater exposure pathways. Background groundwater concentrations will **not** be used to screen COPCs in this risk assessment.

5.6.2 <u>Subtask 6.2: On-site Soil, Groundwater and Soil Gas Investigation</u>

Consistent with the Site data needs listed in Table 10, 14 on-site soil borings, completed as monitoring wells, will be installed as follows:

- Two groundwater monitoring wells (MW-12 and MW-14) along the upgradient (western) Site boundary (Figure 10) to confirm groundwater flow directions and assess potential upgradient or on-site sources;
- Three groundwater monitoring wells in the northern Site interior (MW-13, MW-15, and MW-16) and two groundwater monitoring wells (MW-18 and MW-20) in the southern

Site interior to provide groundwater data (or LNAPL thickness measurements if LNAPL is encountered at these locations), and allow evaluation of temporal groundwater concentration trends and natural attenuation processes;

- Two groundwater monitoring wells (MW-17 and MW-19) along the downgradient (eastern) Site boundary to document dissolved-phase hydrocarbon constituent concentrations at the Site boundary; and
- Five NAPL monitoring wells (NMW-1 through NMW-5) to define the lateral extent of LNAPL and/or DNAPL, or provide NAPL thickness measurements (and temporal thickness trends) if NAPL is encountered. Wells NMW-1 and NMW-5 will be screened above the anticipated potentiometric surface to evaluate the potential presence of LNAPL. Wells NMW-2, NMW-3 and NMW-4 will be screened from above the anticipated potentiometric surface to the base of the uppermost water-bearing unit to evaluate the potential presence of both LNAPL and DNAPL.

These soil borings will be drilled using hollow-stem augers to the top of the Navarro Shale and will be sampled continuously for lithologic purposes. The soil borings will also be continuously logged for relative moisture content, OVM readings, and visual or olfactory evidence of COPCs. It is anticipated that soil samples will be collected for laboratory analysis from the 0 to 0.5 foot depth interval, from a second interval within the 0.5 to 4 feet depth range, and from a third interval within the vadose zone below a depth of 5 feet to be determined based on field observations, including soil headspace measurements using the OVM. The second and third samples for laboratory analysis will be selected to correspond to the highest organic vapor readings and/or visual indications of COPCs within the depth ranges indicated above.

Based on historical site operations and existing data, soil boring samples will be analyzed for VOCs, SVOCs, metals, TPH, and moisture content as indicated in Table 11. Soil data will be compared to the extent evaluation comparison values listed in Table 11 to assess the extent of these COPCs. As noted previously, the extent evaluation comparison values in Table 11 will be updated to reflect current available values at the time of evaluation for all compounds detected and may be revised to account for background concentrations if appropriate due to the presence of background concentrations of a specific COPC in soil.) The soil data will also be used in the human health and ecological risk assessments to evaluate the completeness and significance of the identified potential soil exposure pathways. Background soil concentrations will not be used to screen COPCs in these risk assessments.

One sample of each general soil type will be selected for analysis of total organic carbon, bulk density, moisture content, swell or settlement potential, one-dimensional consolidation testing and compaction characteristics. In addition, three samples of each general soil type will be selected for grain-size distribution and Atterberg Limit tests. Information from these soil tests will be used for evaluating capping-related remedial action alternatives in the FS. Three soil samples will also be analyzed for other potential fate and transport parameters (air-filled porosity, water-filled porosity, and air permeability).

Monitoring wells will be developed by bailing, surging and/or pumping. Following development and a sufficient recovery time, previously existing groundwater monitoring wells, and the newly installed groundwater and NAPL monitoring wells will be gauged for water levels and the possible presence of NAPL. The previously existing and new groundwater monitoring wells will then be purged and sampled using low flow sampling methods with temperature, specific conductance, pH, turbidity, DO and ORP monitored during purging and sampling as described for the off-site groundwater monitoring wells. Hydraulic testing (single-well slug tests) will be performed on one or more representative wells after a sufficient recovery time from sample collection. Hydraulic testing procedures and evaluation methods are described in Section 6.4.3 of the FSP.

Groundwater samples from the groundwater monitoring wells will be analyzed for the VOCs, SVOCs, TPH and metals indicated in Table 12. These data will be compared to the evaluation values provided in Table 12 to delineate the extent of COPCs in groundwater. As noted previously, the extent evaluation comparison values in Table 12 will be updated to reflect current available values at the time of evaluation for all compounds detected and may be revised to account for background concentrations if appropriate due to the presence of background concentrations of a specific COPC in groundwater. The Site groundwater data will also be used in the human health risk assessment to evaluate the completeness and significance of the identified potential exposure pathways. Background groundwater concentrations will not be used to screen COPCs in this risk assessment. Groundwater samples will also be analyzed for nitrate, nitrite, sulfate, and ferrous iron (field measurement) as part of the evaluation of plume behavior and natural attenuation of Site COPCs.

Assuming sufficient sample volumes can be obtained; two representative LNAPL samples will be collected for TPH and VOC analyses and will also be tested for viscosity, density, air/LNAPL interfacial tension, and LNAPL/water interfacial tension. In addition, LNAPL recoverability testing will be performed at selected wells where a sufficient LNAPL thickness is observed. Information from these LNAPL tests will be used for evaluating LNAPL recovery-related remedial action alternatives in the FS.

Pending completion of the soil borings, and after evaluation of the associated data, one or more on-site test pits may be excavated to provide a visual cross-section of potentially impacted soils near the Site boundary. It is anticipated that one of these test pits will be located in the northwestern corner of the Site near US Highway 81 (Figure 2). Depending on the conditions observed, one or more soil samples may be collected for laboratory analysis. If necessary, specific details regarding test pit locations, excavation/sampling procedures, and sample analyses will be proposed following completion of the above soil boring/monitoring well program.

If needed, additional site-specific background soil samples may be collected from within the proposed background area shown on Figure 11. Samples will be collected from the 0 to 0.5 foot depth interval from at least ten locations to allow a statistical evaluation of the background data. Samples will be collected using plastic trowels or hand augers as described in the FSP.

An evaluation of the potential on-site vapor intrusion pathways will be conducted through the collection of subsurface soil gas samples and subslab vapor samples at the Site. Soil gas samples are typically collected to evaluate the pathway (i.e., assess whether VOCs are migrating from a subsurface source into soil gas), and are generally installed close to the vapor source (McHugh and Nickels, 2008). However, based on historical Site operations as described in Section 2.4, it is likely that potential VOC sources may include soils near or slightly below ground surface to the base of the vadose zone, in addition to LNAPL and VOC-containing groundwater. Therefore, at some locations, soil gas samples may be within or below the VOC source area. The placement of soil gas sample points within areas of impacted soils at the Site will provide empirical data to evaluate the partitioning of compounds into the vapor phase.

As shown on Figure 10, soil gas sample locations are proposed adjacent to the nine on-site groundwater monitoring wells to provide co-located soil gas, soil (from soil boring samples), and groundwater data, and thus allow the combined evaluation of these data sets relative to the potential vapor intrusion pathway. The soil gas samples will be collected during a second on-site investigation phase (i.e., subsequent to the installation of soil borings and construction of monitoring wells during the first on-site investigation phase). As such, the proposed locations may be modified based on the site lithology and COPC concentration information obtained from the soil borings/monitoring wells. The soil gas samples will be collected from direct push borings advanced to a depth of approximately 5 to 7 feet below the ground surface. A fritted sampling port will be installed at each soil gas location, the probe hole sealed, and a soil gas sample collected. The soil gas data will be used during the risk assessment to evaluate the potential vapor intrusion risks associated with hypothetical future buildings at the Site.

As a more direct evaluation of the potential for vapor intrusion within the abandoned Site office building, subslab vapor samples will be collected from three locations (to be selected at the time of sampling) within the building. Subslab vapor samples will provide information regarding the presence of VOCs underlying the building slab, but will not indicate whether the source of the VOCs are from an underlying soil, NAPL or groundwater source, or from sources related to the building's usage (e.g., chemical usage/spillage given its apparent use as an on-site laboratory in addition to an office). Like the soil gas samples, the vapor samples will be collected as part of a second on-site investigation phase. The subslab vapor samples will be collected by coring through the concrete floor and installing a sampling port at the base of the slab. The sample location will be sealed and a sample will be collected as described previously. The subslab vapor samples will be used during the risk assessment to evaluate the potential vapor intrusion risks associated under a current hypothetical trespasser scenario.

Soil gas and subslab vapor samples will be collected using Summa canisters. The sample collection time will be dependent on the sample flow rate used, which will be determined based on field conditions. Leak testing will be performed at all sample locations. The soil gas and subslab vapor samples will be analyzed for VOCs listed in Table 14 using EPA Method TO 15.

5.6.3 <u>Subtask 6.3: Off-site Ditch Surface Water Investigation</u>

Based on the Ecological CSM presented in Figure 9, surface water in the off-site drainage ditch west of the Site will be investigated to assess potential risks to mammalian and avian receptors. As discussed in Section 2.2, the ditch is ephemeral and does not provide consistent aquatic habitat, but intermittent mammalian and avian exposure to ditch surface water may occur. Three surface water samples will be collected from the ditch adjacent to the Site and one or more ditch surface water samples will be collected upstream of the Site. The proposed sample locations adjacent to the Site are shown on Figure 10. These locations correspond to areas where ponded water has most often been observed in the ditch. Actual sample locations may be modified based on conditions at the time of sampling and the number and locations of upstream ditch surface water samples will be determined at that time. The collection of ditch surface water samples is subject to the presence of surface water (as indicated by a depth of six inches or more) in the ditch. Ditch surface water samples will be analyzed for VOCs, SVOCs and metals, as indicated in Table 15. Surface water, if present, will be used to evaluate potential ecological risks to avian and mammalian receptors as described in Task 7.

5.7 TASK 7: RISK ASSESSMENTS

A Baseline Human Health Risk Assessment (BHHRA) and Ecological Risk Assessment (ERA) will be prepared for the Site as described in the Settlement Agreement. The Human Health and Ecological Risk Assessment processes and the activities to be performed as part of each are generally described below.

The FSP and QAPP were designed to ensure that data collected during the RI are appropriate for quantitative risk assessment. After RI data collection, the RI data will be subject to validation using procedures specified in the QAPP to ensure that these data are of adequate quality for quantitative risk assessment and to support risk management decisions. Data selected for use in the quantitative risk assessment will be of overall high quality as defined and quantified in the QAPP.

5.7.1 <u>Human Health Risk Assessment</u>

A BHHRA will be conducted for the Site to evaluate and assess the risk to human health posed by COPCs present at the Site. The results of the BHHRA will be used to determine if remedial action is necessary and provide justification for performing any remedial actions.

The risk assessment process described herein uses the methodology that the Superfund Program has established for characterizing the nature and extent of potential risks and for developing and evaluating remedial options. Because it is a risk-based process, risk assessment data needs are considered throughout the RI/FS, from Work Plan development and project scoping to designing and implementing remedial actions identified in the FS. The risk assessment methodology that will be used is based on the risk-based approaches described by EPA in Risk Assessment Guidance for Superfund (RAGS), Volume 1, Human Health Evaluation Manual, Part A (EPA, 1989) and various supplemental and associated guidance documents. The risk assessment process is generally composed of four components:

- COPC identification;
- Exposure assessment;
- Toxicity assessment; and
- Risk characterization.

Contaminant Identification

In order to focus subsequent efforts in the risk assessment process, the RI analytical data will be reviewed and COPCs identified based on the screening processes described in RAGS (EPA 1989).

Toxicity Assessment

The toxicity assessment will consider the types of adverse health or environmental effects associated with individual or multiple exposures, the relationship between magnitude of exposures and adverse effects, and related uncertainties, such as the weight-of-evidence for a chemical's potential adverse effect. Toxicity and dose-response information will be used to generate both qualitative and quantitative estimates of risk associated with the COPCs.

Exposure Assessment

The objectives of the exposure assessment are to more fully characterize potential exposure pathways, to characterize potentially exposed populations, and to determine the levels of potential exposure. Preliminary CSMs described in Section 3.3 provide information related to potentially complete exposure pathways. This section of the risk assessment will further evaluate the CSM in context of the RI data and the BHHRA. The source characteristics and release mechanisms for each COPC will be identified on the basis of the existing data and data generated during the RI/FS. The potential environmental transport and transfer mechanisms will be evaluated to assess migration pathways. The next step will be to identify potential exposure points for identified receptors and describe potential uptake mechanisms when a receptor comes into contact with a COPC in a specific environmental medium.

Once the exposure pathways are understood, the potential for exposure will be assessed. Identification of current and potential land uses in the area where exposure may occur is critical to this assessment. Reasonable maximum exposure (RME) scenarios will be developed, which reflect the nature of the exposures that could occur based on the expected use of the area.

Risk Characterization

The potential risks of adverse health or environmental effects for each of the scenarios described in the exposure assessment will be characterized. The estimates of risk will be obtained by integrating information developed during the toxicity and exposure assessments to characterize the potential or actual risks (carcinogenic, noncarcinogenic and environmental). The risk associated with each potential exposure route for COPCs will be described. Weight-of-evidence issues associated with toxicity data and other uncertainties related to the exposure assessment will be discussed.

A Draft BHHRA will be submitted to EPA for review. A Final BHHRA will be prepared based on EPA's comments on the Draft BHHRA and submitted for EPA approval.

5.7.2 Ecological Risk Assessment

The SOW for the RI/FS at the Site, provided as an Attachment to the Settlement Agreement, requires an Ecological Risk Assessment (ERA). As outlined in the SOW and EPA’s Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (EPA, 1997), the ERA includes an eight-step approach for conducting a scientifically defensible ERA:

1. Screening-Level Problem Formulation and Ecological Effects Evaluation;
2. Screening-Level Preliminary Exposure Estimate and Risk Calculation;

3. Baseline Risk Assessment Problem Formulation;
4. Study Design and Data Quality Objectives;
5. Field Verification of Sampling Design;
6. Site Investigation and Analysis of Exposure and Effects;
7. Risk Characterization; and
8. Risk Management.

Briefly, Steps 1 and 2 of the process are the initial screening phases of the ERA in which existing information is reviewed to preliminarily identify the ecological components that are potentially at risk, the Chemicals of Potential Ecological Concern (COPECs), and the transport and exposure pathways that are important to the ERA. This process is conducted using conservative assumptions to avoid underestimating risk or omitting receptors or COPECs, and constitutes the Screening Level Ecological Risk Assessment (SLERA). In Step 2, a quantitative screening-level risk is estimated using the screening ecotoxicity values developed in Step 1.

Due to the disturbed nature of the Site which lends to poor habitat quality as discussed previously, it is anticipated that Steps 3 through 8 of the ecological risk assessment process will not be necessary. However, to determine whether additional ecological investigation and/or evaluation are necessary, the SLERA will be conducted using maximum Site soil concentrations and hazard quotients will be estimated using TCEQ screening criteria as provided in Table 13. For any compound with an estimated hazard quotient greater than one or that is considered bioaccumulative, a comparison to acute toxicity values will be conducted to provide additional lines of evidence related to potential site risks.

If surface water is present in the ditch during the RI and COPCs are measured in the surface water, these data will be compared to surface water screening levels for mammalian and avian receptors provided in Table 15 (Sample et. al., 1996). Screening levels based on aquatic life protection will not be used to evaluate potential ecological impacts in the ditch since the ditch is ephemeral and the poor habitat quality do not support aquatic life. Likewise, there are no “true” sediments present in the ditch basin so sediment samples will not be collected or evaluated in the SLERA.

As indicated in SOW Paragraph 35(b)(ii), at the end of Step 2, the Respondents will decide, with concurrence from the EPA, whether the information available is adequate to support a risk management decision. The four possible decisions at this point will be: 1) there is adequate information to conclude that ecological risks are negligible and therefore no need for remediation on the basis of ecological risk; 2) the information is not adequate to make a decision at this point, and the ecological risk assessment process will continue to Step 3; 3) the information indicates a potential for adverse ecological effects, and a more thorough assessment is warranted; or 4) there is adequate information to support a risk management decision such as taking action to eliminate an identified exposure pathway. The decision and its basis will be included in the Draft SLERA submitted to EPA for review. A Final SLERA will be prepared based on EPA's comments on the Draft SLERA and submitted for EPA approval.

If performed, Steps 3 through 8 as listed above are conducted in a sequential fashion based on the results and conclusions of the previous step. Step 3 uses the results of the SLERA to identify methods for risk analysis and characterization. Steps 4 through 7 include formalization of the data needs, data collection, and data analysis for the risk characterization and typically comprise the Baseline Ecological Risk Assessment (BERA). It should be noted that if it is determined that a BERA is necessary, bioaccumulative COPCs detected in Site samples will be evaluated in the BERA. Risk management activities are the eighth step in the process.

5.8 TASK 8: TREATABILITY STUDIES

Treatability testing will be performed, if determined necessary by EPA, to assist in the detailed analysis of remedial alternatives. In addition, if applicable, testing results and operating conditions shall be used in the detailed design of the selected remedial technology. Candidate technologies for a treatability studies program will be identified and the need for treatability testing will be considered as the RI/FS proceeds. Treatability studies may consist of laboratory screening, bench-scale testing, and/or pilot-scale testing. The specific data requirements for a treatability testing program will be determined and refined during the characterization of the Site and the development and screening of remedial alternatives. Currently no treatability studies are anticipated; however, should the necessity for treatability testing be determined, a testing Work Plan will be submitted to EPA for review and approval.

5.9 TASK 9: REMEDIAL INVESTIGATION REPORT

Upon completion of all RI data collection and data validation activities, a Draft RI Report will be prepared and submitted to EPA for review. The RI Report format will be based on applicable guidance (EPA, 1988) and will include a summary of the results of the field activities to characterize the Site, classification of groundwater beneath the Site, nature and extent of COPCs, and appropriate site-specific discussions for fate and transport of COPCs. A Final RI Report will be prepared based on EPA's comments on the Draft RI Report and submitted for EPA approval.

5.10 TASK 10: FEASIBILITY STUDY

A Feasibility Study (FS) Report will be will be prepared for the Site. The FS process includes the development and screening of alternatives for remedial action, a detailed analysis of alternatives for remedial action, and submittal of Draft and Final FS Reports as follows:

- Development and Screening of Alternatives for Remedial Action - an appropriate range of remedial alternatives will be evaluated through development and screening.

- Detailed Analyses of Alternatives for Remedial Action - a detailed analysis of remedial alternatives for the candidate remedies identified during the screening process. This detailed analysis will follow the EPA’s guidance document titled “Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA” (EPA 1988) and other appropriate guidance documents. The major components of the detailed analysis of alternatives for remedial action will consist of an analysis of each option against a set of evaluation criteria and a separate discussion for the comparative analysis of all options with respect to each other in a manner consistent with the National Contingency Plan (NCP).

- Draft Feasibility Study Report - a Draft FS Report which documents the activities conducted during the development and screening of alternatives and the detailed analyses of alternatives, as described above, will be prepared and submitted for EPA review. EPA’s guidance document titled “Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA” (EPA 1988), specifically Table

6-5 (Suggested FS Report Format), will be utilized for the suggested FS Report content and format.

- Final Feasibility Study Report – a Final FS Report will be prepared based on EPA's comments (and any public comments provided by EPA) and submitted for EPA approval.

6.0 PROJECTED SCHEDULE

The projected schedule for conducting the RI/FS is shown on Figure 12. This schedule is subject to revision based on changes in assumed EPA review time periods, weather conditions, modifications or additions to the scope of work described herein based on the data obtained, and/or delays in obtaining access to any properties to be sampled. As appropriate, this schedule will be periodically revised and included in Bi-Monthly Progress Reports required under Paragraph 37 of the Settlement Agreement. Bi-Monthly Progress Reports will be submitted by the 10th of every other month with the first report due in the month following EPA approval of the RI/FS Work Plan.

7.0 PROJECT MANAGEMENT PLAN

The management organization for the RI/FS and the key personnel assigned to the project are shown on Figure 13, and the responsibilities of the key players on the project managerial team are described below. The responsibilities of the project management team members, along with identification of the key personnel assigned to the project, are described in the following sections.

7.1 RESPONDENTS' PROJECT COORDINATOR

The Respondents' Project Coordinator will provide the principal point of contact and control for matters concerning the project and field investigation implementation. In consultation with the Respondents, the Respondents' Project Coordinator will:

- Coordinate field investigation activities and develop a detailed schedule;
- Establish project policies and procedures to meet the specific objectives of the project;
- Orient all field staff concerning the project;
- Develop and meet ongoing project staffing requirements, including mechanisms to review and evaluate each work product;
- Review the work performed on each project to help ensure its quality, responsiveness and timeliness; and
- Represent the project team at meetings and public hearings, if necessary.

7.2 REMEDIAL INVESTIGATION MANAGER

The RI Manager will direct and supervise all RI work. The RI Manager's responsibilities will be to review all RI project work to ensure that it meets the specific project goals, meets technical standards, and is in accordance with the objectives and procedures discussed in the RI/FS, FSP, QAPP, and HASP.

7.3 RISK ASSESSMENT MANAGER

The Risk Assessment Manager will direct and supervise all risk assessment activities, including both human health and ecological risk assessment. The Risk Assessment Manager will provide input to the development of the RI Work Plan and will direct all risk-related data evaluation activities. The Risk Assessment Manager's responsibilities will be to ensure that all risk assessment work meets the specific project goals, meets technical standards, and is in accordance with the objectives and procedures discussed in the RI/FS, FSP, QAPP, and HASP.

7.4 FEASIBILITY STUDY MANAGER

The FS Manager will direct and supervise all FS activities, including development and implementation of any treatability studies, assembling of remedial action alternatives and evaluation of these alternatives in the FS. The FS Manager's responsibilities will ensure that all FS activities meets the specific project goals, meets technical standards, and is in accordance with the objectives and procedures discussed in the RI/FS, FSP, QAPP, and HASP.

7.5 QUALITY ASSURANCE MANAGER

The Quality Assurance (QA) Manager will remain independent of direct involvement in day-to-day operations, but will have direct access to staff, as necessary, to resolve any QA issues. The QA Manager has sufficient authority to stop work on the investigation as deemed necessary in the event of serious QA/QC issues. Specific functions and duties include:

- Performing QA audits on various phases of the project's operations, as necessary;
- Reviewing and approving the QAPP and other QA plans and procedures;
- Performing validation of data collected relative to RI/FS activities and the QAPP; and
- Providing QA technical assistance to project staff.

The QA Manager will notify the Project Coordinator of particular circumstances that may adversely affect the quality of data and ensure implementation of corrective actions needed to resolve nonconformances noted during assessments.

7.6 SITE SAFETY OFFICER

The Site Safety Officer (SSO) is the highest ranking safety officer. The SSO has the responsibility of ensuring that all personnel are properly trained and educated, that they abide by the specific health and safety policies, procedures and values contained in the HASP. The SSO will be on call at all times field work is being conducted at the site and vicinity. The SSO will also perform on-site audits of work in progress.

7.7 FIELD SUPERVISOR

The Field Supervisor will be responsible for all aspects of field work performed as part of a specific RI/FS activity. Different project subtasks or activities may have different Field Supervisors. Duties of the Field Supervisor will include:

- Maintaining field records;
- Continually surveying the Site for potential work hazards and relating any new information to site personnel at the Tailgate Safety Meeting held each day prior to beginning field activities;
- Ensuring that field personnel are properly trained, equipped, and familiar with Standard Operating Procedures and the Health and Safety Plan;
- Overseeing sample collection, handling and shipping; ensuring proper functioning of field equipment; and
- Informing the laboratory when samples are shipped to the lab and verifying samples arrived at the lab.

The primary duty of the Field Supervisor is to ensure that the field sampling is performed in accordance with the FSP and QAPP. The Field Supervisor will also require that appropriate personal protective equipment will be worn and disposed of according to the HASP. In addition, the Field Supervisor may be responsible for the preparing monitoring reports for review by the RI Manager.

7.8 SUBCONTRACTORS

Numerous subcontractors will be utilized during the RI/FS investigation to complete the required RI/FS tasks. Subcontractors will be required to comply with the Health and Safety Program prepared for the investigation, and adhere to the applicable requirements of the Work Plan and

Sampling and Analysis Plan to ensure all work is performed appropriately. Specific subcontractors and their responsibilities are presented below:

Environmental Drilling: The environmental drilling subcontractor will be responsible for providing the personnel and equipment necessary to conduct all drilling related tasks identified in the RI/FS project. These tasks include:

- Advancing boreholes for monitoring well and soil gas probe installation (hollow-stem auger, and direct push, respectively);
- Construction of monitoring wells;
- Decontamination of drilling equipment;
- Submittal of state required well registrations;
- Plugging and abandonment of wells (if necessary); and
- Obtaining necessary drilling permits and implementing traffic control plans when drilling in public right of ways.

Surveying: The location and elevation of newly installed monitoring wells, and any other relevant site features, will be surveyed for position by a professional licensed surveyor. The surveyor will be responsible for providing appropriate technical drawings and electronic data in accordance with Section 6.8 of the RI/FS Field Sampling Plan.

Site Maintenance: General mowing and maintenance of the Site is provided by a local subcontractor. The subcontractor provides equipment and personnel to mow the Site, clear brush and shrubs from the fence line, and make minor repairs to site fencing.

8.0 DATA MANAGEMENT PLAN

Data management provides a process for tracing the path of the data from their generation in the field or laboratory to their final use or storage. The following elements are included in this process: recording, validation, transformation, transmittal, reduction, analysis, tracking, and storage and retrieval.

8.1 DATA RECORDING

Sample collection will be documented and tracked using field forms, field logbook entries, and Chain-of-Custody Records. Field personnel will complete these forms, which will then be reviewed for correctness and completeness by the Field Supervisor. Copies of these forms will be maintained in the project files. Examples of field forms are included in the Standard Operating Procedures (SOPs) provided in the FSP.

8.2 DATA VALIDATION

Data validation is addressed in Section 5 of the QAPP. Generally, RI data will be validated by an independent third party validator. Draft and Final reports will include validated data with appropriate flagging. Data rejected during the validation process will not be used and will be discussed in the applicable portions of any final reports. If data is rejected based on issues with performance or QA/QC, corrective action will be taken as described in the QAPP.

8.3 DATA TRANSFORMATION

Since data will be collected and/or reported using proper units according to the QAPP, no data transformation is expected. If data transformation is necessary, the transformation procedures will be added to the QAPP as addenda.

8.4 DATA TRANSMITTAL

The Field Supervisor will be responsible for assuring that field data are entered onto the appropriate field data forms, and will report any problems to the RI Manager. Field Supervisors will submit the complete field data forms to the RI Manager for review and error checking.

Field Supervisors will also ensure that all samples collected in the field are submitted to the laboratory according to the methods outlined in the QAPP or the FSP. The laboratory will submit the analytical results to the RI Manager or Field Supervisor as electronic data deliverables (EDDs) in a spreadsheet format and as a final data report in hard copy or electronic format (i.e., Portable Document Format (PDF)).

Once reviewed by the RI Manager or Field Supervisor for obvious transcription or reporting errors, the final data report will be transmitted and ready for validation by the QA Manager. Following data validation, any data qualifiers added to data during the validation process will be imported into the project database. Entry or upload of EDDs and data qualifiers into the project database will be completed by a designee of the RI Manager. The data and qualifiers will be initially verified by the individual entering the data. Upon completion of the initial verification step, a report will be generated of the data and verified by the RI Manager against the original data. Only final versions of electronic data will be entered into the database. All electronic data will be verified before and after incorporation into the database against the final reports that accompany the data.

All qualified data will be included with the data packages during all subsequent data transmittal processes. The final hard copy data validation checklists will be included with the data in the RI report. All field forms and lab data will be organized and stored by sample location allowing for easy access if needed. Data can be transferred electronically either on disc, CD, or as an email attachment.

8.5 DATA ANALYSIS

Data analysis will be conducted as described on an activity basis in Section 5.0 of this RI/FS WP. Applications that may be utilized to analyze the data include common spreadsheet and database software. The results of data analysis for each activity will be presented in the RI Report.

8.6 DATA STORAGE AND RETRIEVAL

PBW's RI Manager is responsible for project data storage and retrieval. Laboratory data that are provided electronically will be archived electronically, and where printed as part of the paper data report package, will also be archived in paper form. Both the electronic data and hard copies will be maintained in PBW's Round Rock, TX office. In general, all records and data must be retained for a period of 10 years following commencement of construction of any remedial action which is selected following completion of the RI/FS, per Section XIV, Paragraph 55 of the Settlement Agreement.

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TABLES

Table 1 – Site History Summary

Ownership and Operational History

Date	Activity	Key References[1]
1938	Aerial photographs show evidence of refinery operation at both northern and southern tracts of the Site.	TNRCC, 2000
July 1943	Flint Chemical Company purchased two lots in the northern tract.	TNRCC, 2001
December 1950 – October 1974	Refinery operated by Monarch Refining Company/Wing Corporation on certain northern tract lots and on the southern tract lots.	TNRCC, 2001
October 1974	Flint Ink Corporation purchased remaining Site tracts from Wing Corporation, continued to operate a refinery on only the northern tract lots. The southern tract lots were held as vacant land.	TNRCC, 2001
Northern Tract		
1987	Flint Ink Corporation sold northern tract lots to Golden Materials and Supply, Inc. which operated a used oil processing facility.	TNRCC, 2001
February 1989	Eldorado Refining and Marketing, Inc. purchased northern tract and converted operations to waste oil refining. Property was foreclosed on by T.C. Golden, Inc. in 1989.	TNRCC, 2001
Southern Tract		
April 1978	Flint Ink Corporation sold the southern tract lots to Southland Petroleum Company, Inc. who reportedly used the property to distribute petroleum products.	TNRCC, 2001
August 1984	Southland Petroleum Company, Inc. liquidated in bankruptcy, ownership of southern tract acquired by Southern State Bank.	TNRCC, 2001
March 1988	Tropicana Energy Company, Inc. purchased the southern tract lots and began blending ethanol and gasoline.	TNRCC, 2001
April 1992	Tropicana Energy Company, Inc. filed for bankruptcy and abandoned the Site.	TNRCC, 2001

Table 1 – Site History Summary

Regulatory and Investigation History

Date	Activity	Key References[1]
November 12, 1980	City Public Services (CPS) of San Antonio construction crew encountered contaminated groundwater at Hwy 81 (now New Laredo Highway) railroad crossing west of the Site.	TNRCC, 2001
April 1981	Texas Department of Water Resources (TDWR) investigation of groundwater encountered by CPS indicated black, oily liquid with strong gasoline odor present in shallow aquifer.	TNRCC, 2001
October 4, 1983	Approximately 200 gallons of Maranda crude oil spilled at the northern tract. Cleanup of Somerset Road, the adjacent storm sewer, and associated contaminated soils performed immediately following spill.	TNRCC, 2001
January 5, 1985	Approximately 200 gallons of Maranda sweet crude oil spilled at the northern tract in the parking lot and adjacent facility grounds due to overflow from holding tank. Spilled oil was reportedly recovered by facility personnel.	TNRCC, 2001
July 29, 1987	TNRCC conducted a sampling inspection on the northern tract. Waste and soil samples collected.	TNRCC, 2001
August 24, 1988	TNRCC conducted inspection of the northern tract and documented hydrocarbon stained soils near tanks, process areas and railcar loading area.	TNRCC, 2001
September 8, 1988	Based on August 24, 1988 inspection, Golden Materials and Supply, Inc. was issued a Notice of Violation (NOV) for failure to notify the Texas Water Commission (TWC) of the generation of wastes and failure to notify the EPA of their used oil fuel activities.	TNRCC, 2001
April 18-19, 1990	Approximately 8,000 gallons of natural gasoline spilled into bermed area on the southern tract and then flowed outside berm affecting an approximately 700 square yard area.	Raba Kistner, 1991
May 28, 1991	Phase II Remedial Investigation of April 18, 1990 gasoline spill completed by Raba-Kistner Consultants, Inc. Analytical results indicated presence of light to medium-range hydrocarbons in soil and groundwater samples.	Raba Kistner, 1991
December 6, 1995	Compliance Evaluation Inspection (CEI) conducted by TNRCC on northern tract. Samples from the sump, API separator, and soil near the railroad spur were sampled and found to contain hydrocarbon constituents.	TNRCC, 2001

Table 1 – Site History Summary

Date	Activity	Key References[1]
April – October 1998	Removal Assessments performed by EPA contractor, including multi-media sampling and analysis to estimate volumes of on-site materials and evaluate disposal options.	E&E, 1998a; E&E, 1998b
July 1998	TNRCC conducted a Screening Site Inspection (SSI) on the northern tract to determine if sufficient information existed to adequately characterize the waste sources and determine if releases had occurred.	TNRCC, 2000
June 14, 2001	Site proposed to the National Priorities List (NPL).	66 Fed. Reg. 32287 (June 14, 2001)
August – October 2001	Removal Actions performed on both northern and southern tracts of Site. Included removal of containers, equipment, piping, and waste materials.	Weston, 2002a; Weston, 2002b
December 2003	Public Health Assessment Performed for Site	ATSDR, 2003
March & April 2004	Some R&H Oil Company Site Group members voluntarily conducted a preliminary investigation involving the sampling of soil borings and groundwater from monitoring wells on Site and at nearby off-site locations.	ERM, 2004
September - December 2008	Passive soil gas survey performed at Site by EPA contractor.	SAIC, 2008

Note:

[1]Where noted above, TNRCC, 2000 and TNRCC, 2001 serve as secondary references for many of the listed activities. Additional details and primary references are provided in those documents.

Table 2 - Metals Concentrations in Soil

Sample ID	Sample Date	Sample Depth (ft below grade)	Aluminum (mg/kg)	Antimony (mg/kg)	Arsenic (mg/kg)	Barium (mg/kg)	Beryllium (mg/kg)	Cadmium (mg/kg)
R & H								
R-SO-4	7/9/98	0-0.25	1,910	< 13.2	1.8	25.8	< 1.32	< 1.32
R-SO-5	7/9/98	0-0.25	1,070	< 11.1	4.9	23.2	< 1.11	< 1.11
R-SO-6	7/9/98	0-0.25	549	< 10.7	< 1.1	17.7	< 1.06	< 1.06
R-SO-7	7/9/98	0-0.25	3,220	< 10.4	3.3	112.0	< 1.04	< 1.04
R-SO-8	7/9/98	0-0.25	913	< 10.9	41.5	66.8	< 1.09	< 1.09
R-SO-9	7/9/98	0-0.25	1,340	< 10.5	1.9	42.6	< 1.05	< 1.05
R-SO-11	7/9/98	0-0.25	872	< 10.6	5.7	98.8	< 1.06	< 1.06
R-SO-12	7/9/98	Not available	1,600	< 10.4	1.5	13.9	< 1.04	< 1.04
R-SO-13	7/9/98	0-0.25	22,000	< 14.4	6.9	116.0	< 1.44	< 1.44
R-SO-14	7/9/98	0-0.25	16,300	< 13.8	8.8	109.0	< 1.38	< 1.38
R-SO-16	7/9/98	0-2	8,870	< 10.6	3.0	169.0	< 1.06	< 1.06
R-SO-17	7/9/98	0-2	12,400	< 10.9	2.6	162.0	< 1.09	< 1.09
R-SO-18	7/9/98	0-2	1,910	< 10	1.4	42.0	< 1	< 1
R-SO-19	7/9/98	0-2	3,110	< 10.9	1.1 J	22.6	< 1.09	< 1.09
R-SO-20	7/9/98	0-2	1,700	< 10.9	< 1.09	70.4	< 1.09	< 1.09
R-SO-21	7/9/98	0-2	11,300	< 10.4	2.5	90.1	< 1.04	< 1.04
R-SO-22	7/9/98	0-0.25	1,330	< 11.3	2.0	67.5	< 1.13	< 1.13
TROPICANA								
T-SO-1	7/9/98	0-2	11,500	< 10.7	4.1	78.6	< 1.08	< 1.08
T-SO-2	7/9/98	0-2	8,030	< 11.1	2.9	141.0	< 1.11	< 1.11
T-Composite	1/30/91	varies (composite sample)	NA	NA	NA	NA	NA	NA
OFFSITE								
O-SO-15	7/9/98	0-0.25	9,610	< 10.5	2.3	87.9	< 1.04	< 1.04
O-SO-23	7/9/98	Not available	8,270	< 10.4	3.8	97.3	< 1.04	< 1.04
O-SO-24	7/9/98	Not available	6,780	< 12.3	7.2	110.0	< 1.24	< 1.24
O-SO-25	7/9/98	Not available	8,150	< 9.75	6.8	91.4	< 0.97	< 0.97
BACKGROUND								
B-SO-1	7/9/98	0-0.25	8,170	< 11	3.5	65.2	< 1.1	< 1.1
B-SO-2	7/9/98	0-0.25	9,870	< 10.6	2.8	216.0	< 1.06	< 1.06
B-SO-3	7/9/98	0-0.25	8,700	< 10.6	2.7	80.9	< 1.05	< 1.05

Table 2 - Metals Concentrations in Soil

Sample ID	Calcium (mg/kg)	Chromium (mg/kg)	Cobalt (mg/kg)	Copper (mg/kg)	Iron (mg/kg)	Lead (mg/kg)	Magnesium (mg/kg)	Manganese (mg/kg)	Mercury (mg/kg)
R & H									
R-SO-4	23,400	3.4	< 13.2	2.1	1,840	9.5	366	45.5	< 0.13
R-SO-5	15,400	2.7	12.9	2.2	3,670	13.7	185	21.2	< 0.11
R-SO-6	705	2.1	< 10.7	< 1.1	1,060	7.1	45.7	27.3	< 0.11
R-SO-7	79,100	8.9	< 10.4	9.8	6,470	35.7	619	54.0	0.26
R-SO-8	46,900	3.7	406	26.0	12,400	51.7	779	49.3	< 0.11
R-SO-9	226,000	5.3	< 10.5	28.7	2,040	48.1	837	38.6	< 0.11
R-SO-11	205,000	23.8	44.8	37.7	7,690	56.7	874	46.7	0.36
R-SO-12	25,700	3.7	< 10.4	4.0	3,860	25.3	478	35.7	< 0.11
R-SO-13	61,000	22.1	< 14.4	10.1	12,000	136	3,560	208	< 0.14
R-SO-14	69,300	20.1	< 13.8	13.0	9,890	223	2,850	200	0.16
R-SO-16	111,000	10.9	< 10.6	6.0	5,690	77.3	2,110	101	0.26
R-SO-17	97,300	11.1	< 10.9	3.9	8,590	28.2	2,180	143	< 0.11
R-SO-18	256,000	< 1.0	< 10.0	2.4	1,700	6.0	1,610	71.6	< 0.10
R-SO-19	194,000	4.1	< 10.9	4.1	3,170	21.5	682	66.5	< 0.11
R-SO-20	15,000	6.7	< 10.9	26.8	3,410	97.2	346	48.4	< 0.11
R-SO-21	55,000	8.7	< 10.4	1.9	5,700	36.6	2,460	168	< 0.11
R-SO-22	143,000	2.7	< 11.3	13.6	2,530	43.5	764	89.2	< 0.11
TROPICANA									
T-SO-1	162,000	7.5	< 10.7	< 1.1	6,260	8.4	2,550	154	< 0.11
T-SO-2	91,300	10.9	< 11.1	< 1.1	10,200	14.4	3,720	169	< 0.11
T-Composite	NA	NA	NA	NA	NA	22	NA	NA	NA
OFFSITE									
O-SO-15	164,000	22.6	< 10.5	13.6	5,420	260	1,890	101	0.20
O-SO-23	57,800	23.5	< 10.4	15.8	5,610	203	2,330	172	0.50
O-SO-24	175,000	134.0	< 12.3	36.0	5,780	234	2,510	236	0.89
O-SO-25	122,000	84.6	< 9.8	27.9	6,370	186	2,260	207	0.40
BACKGROUND									
B-SO-1	61,000	7.0	< 11.0	6.1	4,850	46.3	1,740	240	< 0.11
B-SO-2	60,900	7.6	< 10.6	3.0	5,950	59.3	2,740	233	< 0.11
B-SO-3	121,000	6.1	< 10.6	6.3	5,110	71.3	1,930	176	< 0.11

Table 2 - Metals Concentrations in Soil

Sample ID	Nickel (mg/kg)	Potassium (mg/kg)	Selenium (mg/kg)	Silver (mg/kg)	Sodium (mg/kg)	Thallium (mg/kg)	Vanadium (mg/kg)	Zinc (mg/kg)
R & H								
R-SO-4	5.0	297	< 1.32	< 1.32	355	< 1.32	< 13.2	22.4
R-SO-5	2.9	135	1.33	< 1.11	258	< 1.11	< 11.1	24.3
R-SO-6	< 1.1	90.6	< 1.06	< 1.06	132	< 1.06	< 10.7	12.4
R-SO-7	3.7	619	< 1.04	< 1.04	165	< 1.04	< 10.4	113
R-SO-8	10.2	111	1.95	< 1.09	415	< 1.09	< 10.9	517
R-SO-9	1.7	227	< 1.05	< 1.05	< 10.5	< 1.05	< 10.5	351
R-SO-11	2.8	92.5	1.48	< 1.06	< 10.6	< 1.06	< 10.6	143
R-SO-12	2.1	222	< 1.04	< 1.04	357	< 1.04	< 10.4	563
R-SO-13	10.4	4,690	< 1.44	< 1.44	376	< 1.44	16.1	183
R-SO-14	9.1	3,730	< 1.38	< 1.38	318	< 1.38	16.0	197
R-SO-16	5.3	2,430	< 1.06	< 1.06	684	< 1.06	13.0	81.5
R-SO-17	7.6	2,970	< 1.09	< 1.09	432	< 1.09	< 10.9	62.8
R-SO-18	< 1.0	510	< 1.00	< 1	< 10	< 1.00	< 10.0	24.6
R-SO-19	2.4	330	< 1.09	< 1.09	119	< 1.09	< 10.9	34.3
R-SO-20	3.9	65.7	< 1.09	< 1.09	327	< 1.09	< 10.9	65.4
R-SO-21	5.4	2,650	< 1.04	< 1.04	466	< 1.04	< 10.4	71.8
R-SO-22	2.0	362	< 1.13	< 1.13	147	< 1.13	< 11.3	76.2
TROPICANA								
T-SO-1	4.5	3,950	< 1.08	< 1.08	12.7	< 1.08	14.1	19.9
T-SO-2	8.2	2,620	< 1.11	< 1.11	244	< 1.11	14.9	46.6
T-Composite	NA	NA	NA	NA	NA	NA	NA	NA
OFFSITE								
O-SO-15	4.2	2,800	< 1.04	< 1.04	83.4	< 1.04	< 10.5	172
O-SO-23	6.9	2,500	< 1.04	< 1.04	330	< 1.04	< 10.8	73.4
O-SO-24	7.4	2,140	< 1.24	< 1.24	289	< 1.24	< 12.3	348
O-SO-25	5.9	2,460	< 0.97	< 0.97	191	< 0.97	< 9.8	250
BACKGROUND								
B-SO-1	6.8	2,800	< 1.10	< 1.1	195	< 1.1	< 11.0	43.8
B-SO-2	5.7	2,670	< 1.06	< 1.06	160	< 1.06	11.3	40.2
B-SO-3	5.3	3,420	< 1.05	< 1.05	60.1	< 1.05	< 10.6	79.1

Notes:
1. NA = Not analyzed.

Table 3 - Volatile Organic Compound Concentrations in Soil

Sample ID	Sample Date	Sample Depth (ft below grade)	2- Butanone (mg/kg)	Benzene (mg/kg)	Ethylbenzene (mg/kg)	Isopropylbenzene (mg/kg)	Napthalene (mg/kg)
R & H							
R-SO-4	07/09/98	0-0.25	< 0.013	< 0.003	< 0.003	< 0.003	< 0.005
R-SO-5	07/09/98	0-0.25	< 1.370	< 0.275	< 0.275	< 0.275	< 0.275
R-SO-6	07/09/98	0-0.25	< 1.340	< 0.269	< 0.269	< 0.269	< 0.269
R-SO-7	07/09/98	0-0.25	< 1.320	< 0.263	< 0.263	< 0.263	< 0.263
R-SO-8	07/09/98	0-0.25	< 1.330	< 0.266	< 0.266	< 0.266	< 0.266
R-SO-9	07/09/98	0-0.25	< 1.370	< 0.275	< 0.275	< 0.275	< 0.275
R-SO-11	07/09/98	0-0.25	< 1.320	< 0.263	< 0.263	< 0.263	< 0.263
R-SO-12	07/09/98	Not available	< 1.330	< 0.266	< 0.266	< 0.266	< 0.266
R-SO-13	07/09/98	0-0.25	< 0.014	< 0.003	< 0.003	< 0.003	< 0.003
R-SO-14	07/09/98	0-0.25	< 1.710	< 0.342	< 0.342	< 0.342	< 0.342
R-SO-16	07/09/98	0-2	< 0.011	< 0.002	< 0.002	< 0.002	< 0.002
R-SO-17	07/09/98	0-2	< 0.054	< 0.011	< 0.011	< 0.011	< 0.011
R-SO-18	07/09/98	0-2	< 1.250	< 0.250	< 0.250	< 0.250	< 0.250
R-SO-19	07/09/98	0-2	< 1.340	< 0.269	< 0.269	< 0.269	< 0.269
R-SO-20	07/09/98	0-2	< 1.390	<	< 0.278	< 0.278	0.868
R-SO-21	07/09/98	0-2	< 1.330	0.681	< 0.266	< 0.266	< 0.266
R-SO-22	07/09/98	0-0.25	< 0.011	< 0.002	0.007	0.002	0.048
R-ERM-SB-6	04/01/04	20-22.5	1.8 J	6.2	43.0	NA[3]	NA
R-ERM-SB-8	03/31/04	19-21.5	1.8	4.0	10.0	NA	NA
R-ERM-SB-11	04/01/04	17.5-20	1.8	0.38 J	5.3	NA	NA
R-ERM-SB-12	04/01/04	17.5-20	< 0.18	0.29 J	23.0	NA	NA
TROPICANA							
T-SO-1	07/09/98	0-2	< 0.011	< 0.002	< 0.002	< 0.002	< 0.002
T-SO-2	07/09/98	0-2	< 0.011	< 0.002	< 0.002	< 0.002	< 0.002
T-2 (4.5')	05/23/90	4.5	NA	< 0.6	< 0.6	NA	NA
T-4 (5')	05/23/90	5	NA	< 0.6	< 0.6	NA	NA
T-MW1 (15 - 17')	10/25/90	15-17	NA	16.0	45.0	NA	NA
T-MW1 (39 - 40')	10/25/90	39-40	NA	< 0.4	< 0.4	NA	NA
T-B3 (10 - 12')	10/25/90	10-12	NA	12.0	21.0	NA	NA
T-B3 (42 - 43')	10/25/90	42-43	NA	< 0.4	< 0.4	NA	NA
T-MW2 (14 - 16')	10/26/90	14-16	NA	< 0.4	6.5	NA	NA
T-MW2 (40 - 42')	10/26/90	40-42	NA	< 0.4	< 0.4	NA	NA
T-B4 (10 - 12')	10/26/90	10-12	NA	< 0.4	< 0.4	NA	NA
T-B4 (42')	10/26/90	42	NA	< 0.4	< 0.4	NA	NA
T-B4 (0 - 2')	10/26/90	0-2	NA	< 0.4	< 0.4	NA	NA
T-B4 (12 - 14')	10/26/90	12-14	NA	< 0.4	< 0.4	NA	NA
T-MW3 (17 - 19')	01/14/91	17-19	NA	81.0	200	NA	NA
T-MW3 (47 - 48')	01/14/91	47-48	NA	< 0.4	< 0.4	NA	NA
T-MW4 (6 - 8')	01/15/91	6-8	NA	< 0.4	< 0.4	NA	NA
T-MW4 (16 - 18')	01/15/91	16-18	NA	< 0.4	0.9	NA	NA
T-MW4 (42 - 44')	01/15/91	42-44	NA	< 0.4	< 0.4	NA	NA
T-MW5 (17 - 19')	01/21/91	17-19	NA	< 0.4	44	NA	NA
T-MW5 (41.5 - 43')	01/21/91	41.5-43	NA	< 0.4	< 0.4	NA	NA
T-MW6 (17 - 19')	01/17/91	17-19	NA	15.0	44.0	NA	NA
T-MW6 (53 - 54.5')	01/17/91	53-54.5	NA	< 0.4	< 0.4	NA	NA
OFFSITE							
O-SO-15	07/09/98	0-0.25	< 0.054	< 0.011	< 0.011	< 0.011	< 0.011
O-SO-23	07/09/98	Not available	< 0.010	< 0.002	< 0.002	< 0.002	< 0.002
O-SO-24	07/09/98	Not available	< 0.013	< 0.003	< 0.003	< 0.003	< 0.003
O-SO-25	07/09/98	Not available	< 0.010	< 0.002	< 0.002	< 0.002	< 0.002
BACKGROUND							
B-SO-1	07/09/98	0-0.25	< 0.011	< 0.002	< 0.002	< 0.002	< 0.002
B-SO-2	07/09/98	0-0.25	< 0.011	< 0.002	< 0.002	< 0.002	< 0.002
B-SO-3	07/09/98	0-0.25	< 0.011	< 0.002	< 0.002	< 0.002	< 0.002

Table 3 - Volatile Organic Compound Concentrations in Soil

Sample ID	n-Propylbenzene (mg/kg)	Toluene (mg/kg)	1, 2, 4-Trimethylbenzene (mg/kg)	1, 3, 5-Trimethylbenzene (mg/kg)	Xylene (mg/kg)
R & H					
R-SO-4	< 0.003	< 0.003	0.004	< 0.003	< 0.004
R-SO-5	< 0.275	< 0.275	< 0.275	< 0.275	< 0.275
R-SO-6	< 0.269	< 0.269	< 0.269	< 0.269	< 0.269
R-SO-7	< 0.263	< 0.263	< 0.263	< 0.263	< 0.263
R-SO-8	< 0.266	< 0.266	< 0.266	< 0.266	< 0.266
R-SO-9	< 0.275	< 0.275	< 0.275	< 0.275	< 0.275
R-SO-11	< 0.263	< 0.263	< 0.263	< 0.263	< 0.263
R-SO-12	< 0.266	< 0.266	< 0.266	< 0.266	< 0.266
R-SO-13	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
R-SO-14	< 0.342	< 0.342	< 0.342	< 0.342	< 0.342
R-SO-16	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
R-SO-17	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011
R-SO-18	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250
R-SO-19	< 0.269	< 0.269	< 0.269	< 0.269	< 0.269
R-SO-20	< 0.278	< 0.278	< 0.278	< 0.278	< 0.278
R-SO-21	< 0.266	< 0.266	< 0.266	< 0.266	< 0.266
R-SO-22	0.007	0.008	0.095	0.033	0.068
R-ERM-SB-6	NA	5.5	NA	NA	170
R-ERM-SB-8	NA	19.0	NA	NA	63.0
R-ERM-SB-11	NA	0.27 J	NA	NA	47.0
R-ERM-SB-12	NA	34.0	NA	NA	240
TROPICANA					
T-SO-1	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
T-SO-2	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
T-2 (4.5')	NA	< 0.6	NA	NA	< 0.6
T-4 (5')	NA	< 0.6	NA	NA	< 0.6
T-MW1 (15 - 17')	NA	< 3.0	NA	NA	8.1
T-MW1 (39 - 40')	NA	< 0.4	NA	NA	< 0.4
T-B3 (10 - 12')	NA	< 3.0	NA	NA	2.5
T-B3 (42 - 43')	NA	< 0.4	NA	NA	< 0.4
T-MW2 (14 - 16')	NA	< 0.4	NA	NA	6.0
T-MW2 (40 - 42')	NA	< 0.4	NA	NA	< 0.4
T-B4 (10 - 12')	NA	< 0.4	NA	NA	5.8
T-B4 (42')	NA	< 0.4	NA	NA	< 0.4
T-B4 (0 - 2')	NA	< 0.4	NA	NA	< 0.4
T-B4 (12 - 14')	NA	< 0.4	NA	NA	< 0.4
T-MW3 (17 - 19')	NA	880	NA	NA	1,500
T-MW3 (47 - 48')	NA	< 0.4	NA	NA	< 0.4
T-MW4 (6 - 8')	NA	2.9	NA	NA	18.0
T-MW4 (16 - 18')	NA	1.3	NA	NA	12.0
T-MW4 (42 - 44')	NA	< 0.4	NA	NA	< 0.4
T-MW5 (17 - 19')	NA	15	NA	NA	140
T-MW5 (41.5 - 43')	NA	< 0.4	NA	NA	< 0.4
T-MW6 (17 - 19')	NA	150	NA	NA	300
T-MW6 (53 - 54.5')	NA	0.8	NA	NA	< 0.4
OFFSITE					
O-SO-15	< 0.011	< 0.011	< 0.011	< 0.011	< 0.011
O-SO-23	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
O-SO-24	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
O-SO-25	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
BACKGROUND					
B-SO-1	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
B-SO-2	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
B-SO-3	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002

Notes:
1. NA = Compound Not Analyzed.
2. J = Estimated value.
3. Only VOCs detected in at least one soil sample are included in this table.

Table 4 - Semi-Volatile Organic Compound Concentrations in Soil

Sample ID	Sample Depth (ft below grade)	Acenapthene (mg/kg)	Acenaphthylene (mg/kg)	Anthracene (mg/kg)	Benzo (a) anthracene (mg/kg)	Benzo (a) pyrene (mg/kg)	Benzo (b) fluoranthene (mg/kg)	Benzo (g, h, i) perylene (mg/kg)	Benzo (k) fluoranthene (mg/kg)
R & H									
R-SO-4	0-0.25	< 175.0	< 175.0	< 175.0	< 175.0	< 175.0	< 175.0	< 175.0	< 175.0
R-SO-5	0-0.25	< 73.3	< 73.3	< 73.3	< 73.3	< 73.3	< 73.3	< 73.3	< 73.3
R-SO-6	0-0.25	< 35.8	< 35.8	< 35.8	< 35.8	< 35.8	< 35.8	< 35.8	< 35.8
R-SO-7	0-0.25	< 105.0	< 105.0	< 105.0	< 105.0	< 105.0	< 105.0	< 105.0	< 105.0
R-SO-8	0-0.25	< 35.4	< 35.4	< 35.4	< 35.4	< 35.4	< 35.4	< 35.4	< 35.4
R-SO-9	0-0.25	< 73.3	< 73.3	< 73.3	< 73.3	< 73.3	< 73.3	< 73.3	< 73.3
R-SO-11	0-0.25	< 70.2	< 70.2	< 70.2	< 70.2	< 70.2	< 70.2	< 70.2	< 70.2
R-SO-12	Not available	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0
R-SO-13	0-0.25	< 9.3	< 9.3	< 9.3	< 9.3	< 9.3	< 9.3	< 9.3	< 9.3
R-SO-14	0-0.25	< 18.2	< 18.2	< 18.2	< 18.2	< 18.2	< 18.2	< 18.2	< 18.2
R-SO-16	0-2	< 14.1	< 14.1	< 14.1	< 14.1	< 14.1	< 14.1	< 14.1	< 14.1
R-SO-17	0-2	< 71.7	< 71.7	< 71.7	< 71.7	< 71.7	< 71.7	< 71.7	< 71.7
R-SO-18	0-2	< 66.7	< 66.7	< 66.7	< 66.7	< 66.7	< 66.7	< 66.7	< 66.7
R-SO-19	0-2	< 14.3	< 14.3	< 14.3	< 14.3	< 14.3	< 14.3	< 14.3	< 14.3
R-SO-20	0-2	< 14.8	< 14.8	< 14.8	< 14.8	< 14.8	< 14.8	< 14.8	< 14.8
R-SO-21	0-2	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0
R-SO-22	0-0.25	< 14.9	< 14.9	< 14.9	< 14.9	< 14.9	< 14.9	< 14.9	< 14.9
TROPICANA									
T-SO-1	0-2	< 0.4	< 0.4	< 0.4	0.194 J	0.312 J	0.258 J	0.161 J	0.312 J
T-SO-2	0-2	< 0.4	< 0.4	< 0.4	0.222 J	0.401	0.344 J	0.233 J	0.356 J
OFFSITE									
O-SO-15	0-0.25	< 14.5	< 14.5	< 14.5	< 14.5	< 14.5	< 14.5	< 14.5	< 14.5
O-SO-23	Not available	< 6.9	< 6.9	< 6.9	< 6.9	< 6.9	< 6.9	< 6.9	< 6.9
O-SO-24	Not available	< 4.2	< 4.2	< 4.2	< 4.2	< 4.2	< 4.2	< 4.2	< 4.2
O-SO-25	Not available	< 3.3	< 3.3	< 3.3	< 3.3	< 3.3	< 3.3	< 3.3	< 3.3
BACKGROUND									
B-SO-1	0-0.25	< 7.1	< 7.1	< 7.1	< 7.1	< 7.1	< 7.1	< 7.1	< 7.1
B-SO-2	0-0.25	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0
B-SO-3	0-0.25	< 7.2	< 7.2	< 7.2	< 7.2	< 7.2	< 7.2	< 7.2	< 7.2

Table 4 - Semi-Volatile Organic Compound Concentrations in Soil

Sample ID	Bis (2-ethylhexyl) phthalate (mg/kg)	Butyl benzyl phthalate (mg/kg)	Chrysene (mg/kg)	Dibenzo (a,h) anthracene (mg/kg)	Diethyl phthalate (mg/kg)	Dimethyl phthalate (mg/kg)	Di-n-butyl phthalate (mg/kg)	Di-n-octyl phthalate (mg/kg)
R & H								
R-SO-4	< 175.0	< 175.0	< 175.0	< 175.0	< 175.0	< 175.0	< 175.0	< 175.0
R-SO-5	< 73.3	< 73.3	< 73.3	< 73.3	< 73.3	< 73.3	< 73.3	< 73.3
R-SO-6	< 35.8	< 35.8	< 35.8	< 35.8	< 35.8	< 35.8	< 35.8	< 35.8
R-SO-7	< 105.0	< 105.0	< 105.0	< 105.0	< 105.0	< 105.0	< 105.0	< 105.0
R-SO-8	35.4	< 35.4	< 35.4	< 35.4	< 35.4	< 35.4	< 35.4	< 35.4
R-SO-9	73.3	< 73.3	< 73.3	< 73.3	< 73.3	< 73.3	< 73.3	< 73.3
R-SO-11	< 70.2	< 70.2	< 70.2	< 70.2	< 70.2	< 70.2	< 70.2	< 70.2
R-SO-12	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0
R-SO-13	< 9.3	< 9.3	< 9.3	< 9.3	< 9.3	< 9.3	< 9.3	< 9.3
R-SO-14	< 18.2	< 18.2	< 18.2	< 18.2	< 18.2	< 18.2	< 18.2	< 18.2
R-SO-16	< 14.1	< 14.1	< 14.1	< 14.1	< 14.1	< 14.1	< 14.1	< 14.1
R-SO-17	< 71.7	< 71.7	< 71.7	< 71.7	< 71.7	< 71.7	< 71.7	< 71.7
R-SO-18	< 66.7	< 66.7	< 66.7	< 66.7	< 66.7	< 66.7	< 66.7	< 66.7
R-SO-19	< 14.3	< 14.3	< 14.3	< 14.3	< 14.3	< 14.3	< 14.3	< 14.3
R-SO-20	< 14.8	< 14.8	< 14.8	< 14.8	< 14.8	< 14.8	< 14.8	< 14.8
R-SO-21	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0
R-SO-22	2.7 J	< 14.9	< 14.9	< 14.9	< 14.9	< 14.9	< 14.9	< 14.9
TROPICANA								
T-S0-1	< 0.4	< 0.4	0.269 J	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
T-SO-2	< 0.4	< 0.4	0.289 J	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
OFFSITE								
O-SO-15	< 14.5	< 14.5	< 14.5	< 14.5	< 14.5	< 14.5	< 14.5	< 14.5
O-SO-23	< 6.9	< 6.9	< 6.9	< 6.9	< 6.9	< 6.9	< 6.9	< 6.9
O-SO-24	< 4.2	< 4.2	< 4.2	< 4.2	< 4.2	< 4.2	< 4.2	< 4.2
O-SO-25	< 3.3	< 3.3	< 3.3	< 3.3	< 3.3	< 3.3	< 3.3	< 3.3
BACKGROUND								
B-SO-1	< 7.1	< 7.1	< 7.1	< 7.1	< 7.1	< 7.1	< 7.1	< 7.1
B-SO-2	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0
B-SO-3	< 7.2	< 7.2	< 7.2	< 7.2	< 7.2	< 7.2	< 7.2	< 7.2

Table 4 - Semi-Volatile Organic Compound Concentrations in Soil

Sample ID	Fluoranthene (mg/kg)	Fluorene (mg/kg)	Indeno (1, 2, 3-cd) pyrene (mg/kg)	Phenanthrene (mg/kg)	Pyrene (mg/kg)
R & H					
R-SO-4	< 175.0	< 175.0	< 175.0	< 175.0	< 175.0
R-SO-5	< 73.3	< 73.3	< 73.3	< 73.3	< 73.3
R-SO-6	< 35.8	< 35.8	< 35.8	< 35.8	< 35.8
R-SO-7	< 105.0	< 105.0	< 105.0	< 105.0	< 105.0
R-SO-8	< 35.4	< 35.4	< 35.4	< 35.4	< 35.4
R-SO-9	< 73.3	< 73.3	< 73.3	< 73.3	< 73.3
R-SO-11	< 70.2	< 70.2	< 70.2	< 70.2	< 70.2
R-SO-12	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0
R-SO-13	< 9.3	< 9.3	< 9.3	< 9.3	< 9.3
R-SO-14	< 18.2	< 18.2	< 18.2	< 18.2	< 18.2
R-SO-16	< 14.1	< 14.1	< 14.1	< 14.1	14.1
R-SO-17	< 71.7	< 71.7	< 71.7	< 71.7	< 71.7
R-SO-18	< 66.7	< 66.7	< 66.7	< 66.7	< 66.7
R-SO-19	< 14.3	< 14.3	< 14.3	< 14.3	< 14.3
R-SO-20	< 14.8	< 14.8	< 14.8	< 14.8	< 14.8
R-SO-21	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0
R-SO-22	< 14.9	< 14.9	< 14.9	< 14.9	< 14.9
TROPICANA					
T-S0-1	0.247 J	< 0.4	0.151 J	< 0.4	0.215 J
T-SO-2	0.278 J	< 0.4	0.218 J	< 0.4	0.244 J
OFFSITE					
O-SO-15	< 14.5	< 14.5	< 14.5	< 14.5	< 14.5
O-SO-23	< 6.9	< 6.9	< 6.9	< 6.9	< 6.9
O-SO-24	< 4.2	< 4.2	< 4.2	< 4.2	< 4.2
O-SO-25	< 3.3	< 3.3	< 3.3	< 3.3	< 3.3
BACKGROUND					
B-SO-1	< 7.1	< 7.1	< 7.1	< 7.1	< 7.1
B-SO-2	< 7.0	< 7.0	< 7.0	< 7.0	< 7.0
B-SO-3	< 7.2	< 7.2	< 7.2	< 7.2	< 7.2

Notes:
1. J = Estimated value.
2. All samples were collected on July 9, 1998.

Table 5 - Pesticide Concentrations in Soil

Sample ID	Sample Depth (ft below grade)	4, 4' - DDE (mg/kg)	4, 4' - DDT (mg/kg)	alpha-chlordane (mg/kg)	gamma-chlordane (mg/kg)
R & H					
R-SO-4	0-0.25	< 0.088	< 0.088	< 0.044	< 0.044
R-SO-5	0-0.25	< 0.366	< 0.366	< 0.183	< 0.183
R-SO-6	0-0.25	< 0.179	< 0.179	< 0.090	< 0.090
R-SO-7	0-0.25	< 1.050	< 1.050	< 0.526	< 0.526
R-SO-8	0-0.25	< 0.177	< 0.177	< 0.089	< 0.089
R-SO-9	0-0.25	< 0.183	< 0.183	< 0.092	< 0.092
R-SO-11	0-0.25	< 0.351	< 0.351	< 0.175	< 0.175
R-SO-12	Not available	< 0.018	< 0.018	< 0.009	< 0.009
R-SO-13	0-0.25	< 0.094	< 0.094	< 0.047	< 0.047
R-SO-14	0-0.25	< 0.091	< 0.091	< 0.046	< 0.046
R-SO-16	0-2	< 0.035	< 0.035	< 0.018	< 0.018
R-SO-17	0-2	< 0.072	< 0.072	< 0.036	< 0.036
R-SO-18	0-2	< 0.017	< 0.017	< 0.008	< 0.008
R-SO-19	0-2	< 0.072	< 0.072	< 0.036	< 0.036
R-SO-20	0-2	< 0.019	< 0.019	< 0.009	< 0.009
R-SO-21	0-2	< 0.071	< 0.071	< 0.035	< 0.035
R-SO-22	0-0.25	< 0.075	< 0.075	< 0.037	< 0.037
TROPICANA					
T-SO-1	0-2	< 0.004	< 0.004	0.012	0.010
T-SO-2	0-2	< 0.004	< 0.004	0.003	0.00148 J
OFFSITE					
O-SO-15	0-0.25	< 0.036	< 0.036	< 0.018	< 0.018
O-SO-23	Not available	< 0.003	< 0.003	< 0.002	< 0.002
O-SO-24	Not available	< 0.083	< 0.083	< 0.042	< 0.042
O-SO-25	Not available	< 0.067	< 0.067	< 0.033	< 0.033
BACKGROUND					
B-SO-1	0-0.25	< 0.004	< 0.004	0.00072 J	0.003
B-SO-2	0-0.25	< 0.004	< 0.004	< 0.002	< 0.002
B-SO-3	0-0.25	0.030	**0.058**	< 0.002	< 0.002

Notes:
1. J = Estimated value.
2. All samples were collected on July 9, 1998.
3. Only pesticides detected in at least one soil sample are included in this table.

Table 6 - Metals Concentrations in Groundwater

Well ID	Date Sampled	Aluminum (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Calcium (mg/L)	Iron (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Potassium (mg/L)	Sodium (mg/L)	Zinc (mg/L)
T-MW-01	7/8/98	< 0.05	0.073	0.537	106	10.2	10.9	0.372	1.78	140	< 0.02
T-MW-02	7/8/98	0.064	0.557	0.152	99.2	8.51	10.1	0.744	2.73	307	< 0.02
T-MW-04	7/8/98	0.098	0.061	0.372	103	4.48	8.31	0.513	3.83	162	0.112
T-MW-05	7/8/98	< 0.05	0.111	0.305	101	7.68	12.5	0.607	1.28	132	< 0.02
T-MW-05	7/8/98	< 0.05	0.108	0.297	98.9	7.44	12.2	0.59	1.24	129	< 0.02

Table 7 - Volatile Organic Compound Concentrations in Groundwater

Well ID	Sample Date	Acetone (mg/L)	Benzene (mg/L)	2-Butanone (mg/L)	cis-1, 2-Dichloroethene (mg/L)
R & H TEMPORARY WELLS					
R-ERM-SB-07	3/31/04	0.052	0.65	0.0096 J	< 0.00074
R-ERM-SB-09	3/31/04	< 0.0012	2.2	< 0.0007	0.0062
R-ERM-SB-10	4/2/04	< 0.0012	24	0.0380	0.0052
R-ERM-SB-10	4/2/04	< 0.0012	23	0.030	0.0047 J
R-ERM-SB-11	4/1/04	< 0.0012	2.8	0.047	0.0190
R-ERM-SB-11	4/1/04	< 0.0012	2.8	0.039	0.0170
R-ERM-SB-12	4/1/04	< 0.0012	37	0.038	0.0024 J
TROPICANA WELLS					
T-MW-01	11/20/90	< 5.0	< 0.3	< 5	< 0.3
T-MW-01	7/8/98	< 0.01	1.97	< 0.01	< 0.002
T-MW-02	11/20/90	NA	0.95	NA	NA
T-MW-02	7/8/98	< 0.01	0.782	< 0.01	< 0.002
T-MW-02	3/31/04	< 0.0012	0.43	< 0.0007	0.0011 J
T-MW-02	3/31/04	< 0.0012	0.37	< 0.0007	0.00099 J
T-MW-03	1/25/91	NA	0.066	NA	NA
T-MW-03	1/29/91	NA	2.6	NA	NA
T-MW-03	9/28/95	Note: LNAPL detected in well, no water sample collected			
T-MW-03	7/9/98	Note: LNAPL detected in well, no water sample collected			
T-MW-03	3/31/04	Note: LNAPL detected in well, no water sample collected			
T-MW-04	1/25/91	NA	55	NA	NA
T-MW-04	1/29/91	NA	0.7	NA	NA
T-MW-04	7/8/98	< 0.01	0.163	< 0.01	< 0.002
T-MW-04	3/31/04	< 0.0012	< 0.0007	< 0.0007	< 0.00074
T-MW-05	2/5/91	NA	2	NA	NA
T-MW-05	7/8/98	< 0.01	0.369	< 0.01	< 0.002
T-MW-05	7/8/98	< 0.01	0.408	< 0.01	< 0.002
T-MW-05	3/31/04	Note: LNAPL detected in well, no water sample collected			
T-MW-06	2/5/91	NA	0.29	NA	NA
T-MW-06	9/28/95	Note: LNAPL detected in well, no water sample collected			
T-MW-06	7/8/98	Note: LNAPL detected in well, no water sample collected			
T-MW-06	3/31/04	Note: LNAPL detected in well, no water sample collected			
OFF-SITE TEMPORARY WELLS					
O-ERM-SB-01	3/30/04	< 0.0012	0.07	< 0.0007	< 0.0016 J
O-ERM-SB-02	3/30/04	0.12	0.006	< 0.0007	< 0.00074
O-ERM-SB-03	3/30/04	< 0.0012	0.00091 J	< 0.0007	< 0.00074
O-ERM-SB-04	3/30/04	< 0.0012	0.00082 J	< 0.0007	0.0096

Table 7 - Volatile Organic Compound Concentrations in Groundwater

Well ID	Sample Date	1, 1-Dichloroethene (mg/L)	Ethylbenzene (mg/L)	Isopropylbenzene (mg/L)	Tetrachloroethene (mg/L)
R & H TEMPORARY WELLS					
R-ERM-SB-07	3/31/04	< 0.00053	0.0034 J	NA	< 0.00043
R-ERM-SB-09	3/31/04	< 0.00053	0.17	NA	< 0.00043
R-ERM-SB-10	4/2/04	< 0.00053	1.2	NA	< 0.00043
R-ERM-SB-10	4/2/04	< 0.00053	1.5	NA	< 0.00043
R-ERM-SB-11	4/1/04	< 0.00053	0.89	NA	0.00064 J
R-ERM-SB-11	4/1/04	< 0.00053	0.79	NA	0.00065 J
R-ERM-SB-12	4/1/05	< 0.00053	1.7	NA	< 0.00043
TROPICANA WELLS					
T-MW-01	11/20/90	< 0.3	< 0.3	NA	< 0.3
T-MW-01	7/8/98	< 0.002	0.0835	0.0939	< 0.002
T-MW-02	11/20/90	0.002	0.033	NA	NA
T-MW-02	7/8/98	< 0.002	0.0443	0.045	< 0.002
T-MW-02	3/31/04	< 0.00053	0.0022 J	NA	< 0.00043
T-MW-02	3/31/04	< 0.00053	0.0018 J	NA	< 0.00043
T-MW-03	1/25/91	NA	1.6	NA	NA
T-MW-03	1/29/91	NA	0.7	NA	NA
T-MW-03	9/28/95	Note: LNAPL detected in well, no water sample collected			
T-MW-03	7/9/98	Note: LNAPL detected in well, no water sample collected			
T-MW-03	3/31/04	Note: LNAPL detected in well, no water sample collected			
T-MW-04	1/25/91	NA	0.04	NA	NA
T-MW-04	1/29/91	NA	0.05	NA	NA
T-MW-04	7/8/98	< 0.002	< 0.002	0.0026	< 0.002
T-MW-04	3/31/04	< 0.00053	< 0.00077	NA	< 0.00043
T-MW-05	2/5/91	NA	0.02	NA	NA
T-MW-05	7/8/98	< 0.002	< 0.002	0.0108	< 0.002
T-MW-05	7/8/98	< 0.002	< 0.002	0.0123	< 0.002
T-MW-05	3/31/04	Note: LNAPL detected in well, no water sample collected			
T-MW-06	2/5/91	NA	0.14	NA	NA
T-MW-06	9/28/95	Note: LNAPL detected in well, no water sample collected			
T-MW-06	7/8/98	Note: LNAPL detected in well, no water sample collected			
T-MW-06	3/31/04	Note: LNAPL detected in well, no water sample collected			
OFF-SITE TEMPORARY WELLS					
O-ERM-SB-01	3/30/04	< 0.00053	0.0017 J	NA	0.0016 J
O-ERM-SB-02	3/30/04	< 0.00053	0.26	NA	< 0.00043
O-ERM-SB-03	3/30/04	< 0.00053	< 0.00077	NA	< 0.00043
O-ERM-SB-04	3/30/04	0.0011 J	< 0.00077	NA	0.0092

Table 7 - Volatile Organic Compound Concentrations in Groundwater

Well ID	Sample Date	Toulene (mg/L)	Trichloroethene (mg/L)	Vinyl Chloride (mg/L)	Xylenes (mg/L)
R & H TEMPORARY WELLS					
R-ERM-SB-07	3/31/04	0.013	< 0.0007	< 0.00079	0.017
R-ERM-SB-09	3/31/04	0.052	0.00096 J	< 0.00079	0.32
R-ERM-SB-10	4/2/04	24	< 0.0007	< 0.00079	9.1
R-ERM-SB-10	4/2/04	24	< 0.0007	< 0.00079	8.7
R-ERM-SB-11	4/1/04	3.1	0.0013 J	0.0087	6.3
R-ERM-SB-11	4/1/04	3.0	0.0013 J	0.0093	6.1
R-ERM-SB-12	4/1/05	17	< 0.0007	< 0.00079	14
TROPICANA WELLS					
T-MW-01	11/20/90	< 0.3	< 0.3	< 0.5	< 0.30
T-MW-01	7/8/98	0.017	< 0.002	< 0.002	0.02
T-MW-02	11/20/90	< 0.005	NA	NA	0.08
T-MW-02	7/8/98	0.0075	< 0.002	< 0.002	0.02
T-MW-02	3/31/04	0.0039 J	< 0.0007	< 0.00079	0.0035 J
T-MW-02	3/31/04	0.0035 J	< 0.0007	< 0.00079	0.0034 J
T-MW-03	1/25/91	0.25	NA	NA	0.24
T-MW-03	1/29/91	**7.3**	NA	NA	6.60
T-MW-03	9/28/95	Note: LNAPL detected in well, no water sample collected			
T-MW-03	7/9/98	Note: LNAPL detected in well, no water sample collected			
T-MW-03	3/31/04	Note: LNAPL detected in well, no water sample collected			
T-MW-04	1/25/91	24	NA	NA	36
T-MW-04	1/29/91	0.06	NA	NA	0.23
T-MW-04	7/8/98	0.0028	< 0.002	< 0.0021	0.003
T-MW-04	3/31/04	< 0.00069	< 0.0007	< 0.00079	< 0.0018
T-MW-05	2/5/91	0.008	NA	NA	0.03
T-MW-05	7/8/98	0.0021	< 0.002	< 0.002	0.003
T-MW-05	7/8/98	0.0043	< 0.002	< 0.002	0.003
T-MW-05	3/31/04	Note: LNAPL detected in well, no water sample collected			
T-MW-06	2/5/91	2	NA	NA	1.60
T-MW-06	9/28/95	Note: LNAPL detected in well, no water sample collected			
T-MW-06	7/8/98	Note: LNAPL detected in well, no water sample collected			
T-MW-06	3/31/04	Note: LNAPL detected in well, no water sample collected			
OFF-SITE TEMPORARY WELLS					
O-ERM-SB-01	3/30/04	< 0.00069	0.003 J	< 0.00079	< 0.0018
O-ERM-SB-02	3/30/04	0.0008 J	< 0.0007	< 0.00079	0.095
O-ERM-SB-03	3/30/04	0.001 J	< 0.0007	< 0.00079	< 0.0018
O-ERM-SB-04	3/30/04	0.00086 J	0.043	< 0.00079	< 0.0018

Notes:
1. NA = compound not analyzed.
2. Only VOCs detected in at least one groundwater sample are included in this table.

Table 8 - Semi-Volatile Organic Compound Concentrations in Groundwater

Well ID	Date Sampled	2, 4-Dimethylphenol (mg/L)	2-Methylnaphthalene (mg/L)	Napthalene (mg/L)	Phenol (mg/L)
T-MW-01	8-Jul-98	0.005 J	0.0937	0.108	0.005 J
T-MW-02	8-Jul-98	< 0.010	0.0121	0.011	< 0.010
T-MW-04	8-Jul-98	< 0.010	< 0.0100	< 0.010	< 0.010
T-MW-05	8-Jul-98	< 0.012	0.0984	< 0.0118	0.005 J
T-MW-05	8-Jul-98	< 0.010	0.0857	< 0.010	0.009 J

Notes:
1. Only SVOCs detected in at least one groundwater sample are included in this table.

Table 9 - Selected Former East Kelly Air Force Base Groundwater Monitoring Well Data

Well ID	Sampling Date	Benzene (mg/L)	Toluene (mg/L)	Ethylbenzene (mg/L)	Xylene (mg/L)	Trichloro-ethylene (mg/L)	Tetrachloro-ethylene (mg/L)	1,2-Dichloroethene (mg/L)
SS052MW098	5/10/2001	<0.001	<0.001	<0.001	<0.001	0.037	0.0048	0.01
SS052MW098	4/22/2002	<0.001	<0.001	<0.001	<0.001	0.0283	0.00511	0.00746
SS052MW098	4/14/2003	<0.001	0.00026 J	<0.001	<0.001	0.0391	0.00301	0.0168
SS052MW098	4/16/2004	<0.001	0.00057 J	<0.001	<0.001	0.025	0.00211	0.0115
SS052MW098	4/13/2005	<0.001	0.00009 J	<0.001	<0.001	0.0243	0.00203	0.0091
SS052MW098	5/23/2006	<0.00015	<0.00016	<0.00035	<0.00037	0.0189	0.0048	0.005
SS052MW098	4/18/2007	na	na	na	na	0.014	0.0031 J	0.0045
SS052MW098	4/2/2008	na	na	na	na	0.021	0.0035	0.0085
SS052MW098	4/22/2009	na	na	na	na	0.0124	0.00763	0.00362
SS052MW122	5/11/2001	<0.001	<0.001	<0.001	<0.001	0.016	0.028	0.066
SS052MW122	4/22/2002	<0.001	<0.001	<0.001	<0.001	0.00658	0.0209	0.0245
SS052MW122	4/15/2003	<0.001	<0.001	<0.001	<0.001	0.00433	0.0167	0.0134
SS052MW122	4/19/2004	<0.001	0.00039 J	<0.001	<0.001	0.00164	0.00441	0.00483
SS052MW122	4/13/2005	<0.001	<0.001	<0.001	<0.001	0.00265	0.0102	0.00868
SS052MW122	6/12/2006	<0.00015	<0.00016	<0.00035	<0.00037	0.0022	0.0048	0.0046
SS052MW122	6/1/2007	na	na	na	na	0.0026	0.0031	0.0032
SS052MW122	4/1/2008	na	na	na	na	0.0023	0.0026	0.0035
SS052MW122	4/22/2009	na	na	na	na	0.00302	0.00538	0.00337
SS052MW132	5/10/2001	<0.001	<0.001	<0.001	<0.001	0.0058	0.0047	0.0024
SS052MW132	4/26/2002	<0.001	<0.001	<0.001	<0.001	0.0335	0.00528	0.00437
SS052MW132	4/14/2003	<0.001	0.00046 J	<0.001	<0.001	0.00894	0.00867	0.00325
SS052MW132	4/16/2004	0.00005 J	0.00077 J	<0.001	<0.001	0.00501	0.0072	0.0021
SS052MW132	4/13/2005	<0.001	0.00009 J	<0.001	<0.001	0.00845	0.0108	0.00297
SS052MW132	6/12/2006	<0.00015	<0.00016	<0.00035	<0.00037	0.0045	0.008	0.0019
SS052MW132	4/18/2007	na	na	na	na	0.0031	0.0047 J	0.0011
SS052MW132	4/2/2008	na	na	na	na	0.0058	0.01	0.0029
SS052MW132	4/22/2009	na	na	na	na	0.00368	0.00832	0.00134 J
SS052MW190	5/15/2001	<0.001	0.00033 J	<0.001	<0.001	0.026	0.034	0.1
SS052MW190	4/11/2002	0.00011 J	<0.001	<0.001	<0.001	0.0193	0.0257	0.0931
SS052MW190	4/3/2003	0.00015 J	<0.001	<0.001	<0.001	0.0144	0.0156	0.0664
SS052MW190	4/19/2004	0.00006 J	<0.001	<0.001	<0.001	0.0106	0.012	0.0564
SS052MW190	4/6/2005	<0.001	<0.001	<0.001	<0.001	0.0093	0.00921	0.0452
SS052MW190	5/25/2006	<0.00015	<0.00016	<0.00035	<0.00037	0.0085	0.0054	0.0385
SS052MW190	4/16/2007	na	na	na	na	0.0086	0.007	0.031
SS052MW190	4/4/2008	na	na	na	na	0.0062	0.0046	0.021
SS052MW190	4/9/2009	na	na	na	na	0.00408	0.00477	0.017
SS052MW200	5/15/2001	<0.001	0.00042 J	<0.001	<0.001	0.001	<0.001	0.0012
SS052MW200	4/23/2002	<0.001	<0.001	<0.001	<0.001	0.0002 J	0.00024 J	0.00062 J
SS052MW200	4/4/2003	<0.001	0.00049 J	<0.001	<0.001	0.00598	0.00222	0.00245
SS052MW200	4/9/2004	0.00007 J	0.00044 J	<0.001	<0.001	0.0023	0.00118	0.00383
SS052MW200	4/6/2005	<0.001	<0.001	<0.001	<0.001	0.00648	0.00341	0.00651
SS052MW200	6/13/2006	<0.00015	<0.00016	<0.00035	<0.00037	0.0084	0.0078	0.0026
SS052MW200	4/17/2007	na	na	na	na	0.0037	0.0042	0.0013
SS052MW200	4/7/2008	na	na	na	na	0.0042	0.0048	0.0013 J
SS052MW200	4/17/2009	na	na	na	na	0.00391	0.00755	0.00133 J

Table 9 - Selected Former East Kelly Air Force Base Groundwater Monitoring Well Data

Well ID	Sampling Date	Benzene (mg/L)	Toluene (mg/L)	Ethylbenzene (mg/L)	Xylene (mg/L)	Trichloro-ethylene (mg/L)	Tetrachloro-ethylene (mg/L)	1,2-Dichloroethene (mg/L)
SS052MW210	5/15/2001	<0.001	0.00048 J	<0.001	<0.001	0.013	0.005	0.0052
SS052MW210	4/23/2002	0.00029 J	<0.001	<0.001	<0.001	0.0169	0.0071	0.00689
SS052MW210	4/7/2003	<0.001	<0.001	<0.001	<0.001	0.0212	0.00986	0.00509
SS052MW210	4/7/2004	0.00011 J	0.00054 J	<0.001	<0.001	0.0104	0.00444	0.00349
SS052MW210	4/6/2005	<0.001	<0.001	<0.001	<0.001	0.0159	0.00699	0.00423
SS052MW210	6/12/2006	<0.00015	<0.00016	<0.00035	<0.00037	0.0184	0.0077	0.0043
SS052MW210	5/3/2007	na	na	na	na	0.015	0.0055	0.004
SS052MW210	4/4/2008	na	na	na	na	0.017	0.006	0.0041
SS052MW210	4/17/2009	na	na	na	na	0.0131	0.00813	0.00412
SS052MW213	5/15/2001	<0.001	0.00062 J	<0.001	<0.001	<0.001	<0.001	<0.001
SS052MW213	4/11/2002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SS052MW213	4/4/2003	<0.001	0.00088 J	<0.001	<0.001	<0.001	<0.001	<0.001
SS052MW213	4/19/2004	0.00008 J	0.00049 J	<0.001	<0.001	<0.001	0.00005 J	<0.001
SS052MW213	4/6/2005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SS052MW213	6/13/2006	<0.00015	<0.00016	<0.00035	<0.00037	<0.00027	<0.0005	<0.0002
SS052MW213	5/3/2007	na	na	na	na	<0.00013	<0.00018	<0.00034
SS052MW213	4/3/2008	na	na	na	na	<0.0002	<0.00014	<0.0003
SS052MW213	5/8/2009	na	na	na	na	<0.000097	<0.0001	<0.000198
SS052MW270	5/14/2001	<0.001	<0.001	<0.001	<0.001	0.08	0.0068	0.02
SS052MW270	4/9/2002	0.00028 J	<0.001	<0.001	<0.001	0.0362	0.00327	0.0137
SS052MW270	4/7/2003	<0.001	0.00024 J	<0.001	<0.001	0.031	0.00453	0.00807
SS052MW270	4/8/2004	<0.001	0.00037 J	<0.001	<0.001	0.0301	0.00392	0.00912
SS052MW270	4/8/2005	<0.001	<0.001	<0.001	<0.001	0.029	0.00359	0.00933
SS052MW270	5/25/2006	<0.00015	<0.00016	<0.00035	<0.00037	0.0346	0.0029	0.0105
SS052MW270	5/4/2007	na	na	na	na	0.018	0.0028	0.0064
SS052MW270	4/9/2008	na	na	na	na	0.018	0.0032	0.0058
SS052MW270	4/20/2009	na	na	na	na	0.0168	0.00741	0.0092
SS052MW272	5/14/2001	<0.001	<0.001	<0.001	0.001	0.032	0.011	0.0074
SS052MW272	4/9/2002	<0.001	<0.001	<0.001	<0.001	0.0277	0.00877	0.00628
SS052MW272	4/7/2003	<0.001	0.00025 J	<0.001	<0.001	0.0295	0.0109	0.00641
SS052MW272	4/8/2004	<0.001	0.00025 J	<0.001	<0.001	0.0284	0.0109	0.00644
SS052MW272	4/1/2005	<0.001	<0.001	<0.001	<0.001	0.0288	0.0106	0.00652
SS052MW272	5/16/2006	<0.00015	<0.00016	<0.00035	<0.00037	0.0361	0.0099	0.0074
SS052MW272	4/16/2007	na	na	na	na	0.026	0.0075	0.0058
SS052MW272	4/7/2008	na	na	na	na	0.023	0.0073	0.0051
SS052MW272	4/20/2009	na	na	na	na	0.0199	0.0125	0.0061
SS052MW273	5/15/2001	<0.001	0.00029 J	<0.001	<0.001	<0.001	0.0012	0.002
SS052MW273	4/9/2002	0.00013 J	<0.001	<0.001	<0.001	0.00736	0.00212	0.00141
SS052MW273	4/7/2003	<0.001	0.00033 J	<0.001	<0.001	0.0111	0.00244	0.00239
SS052MW273	4/7/2004	0.00017 J	0.00044 J	<0.001	<0.001	0.00821	0.00229	0.00185
SS052MW273	4/6/2005	0.00008 J	<0.001	<0.001	<0.001	0.0108	0.00368	0.00237
SS052MW273	5/15/2006	<0.00015	<0.00016	<0.00035	<0.00037	0.0136	0.0035	0.0032
SS052MW273	4/16/2007	na	na	na	na	0.0075	0.0018	0.0021
SS052MW273	4/7/2008	na	na	na	na	0.011	0.0032	0.0026
SS052MW273	4/20/2009	na	na	na	na	0.00805	0.00593	0.00278

Table 9 - Selected Former East Kelly Air Force Base Groundwater Monitoring Well Data

Well ID	Sampling Date	Benzene (mg/L)	Toluene (mg/L)	Ethylbenzene (mg/L)	Xylene (mg/L)	Trichloro-ethylene (mg/L)	Tetrachloro-ethylene (mg/L)	1,2-Dichloroethene (mg/L)
SS052MW275	6/6/2001	<0.001	<0.001	<0.001	<0.001	0.012	0.0092	0.0058
SS052MW275	4/9/2002	<0.001	<0.001	<0.001	<0.001	0.00831	0.00871	0.00426
SS052MW275	4/7/2003	<0.001	0.00028 J	<0.001	<0.001	0.00772	0.00762	0.00382
SS052MW275	4/7/2004	<0.001	<0.001	<0.001	<0.001	0.0083	0.00649	0.00338
SS052MW275	4/6/2005	<0.001	<0.001	<0.001	<0.001	0.0102	0.00656	0.00341
SS052MW275	6/1/2006	<0.00015	0.00021 J	<0.00035	<0.00037	0.014	0.0053	0.0036
SS052MW275	5/4/2007	na	na	na	na	0.0093	0.0042	0.003
SS052MW275	4/4/2008	na	na	na	na	0.011	0.0059	0.0037
SS052MW275	4/22/2009	na	na	na	na	0.00894	0.0098	0.00332
SS052MW592	6/6/2001	ns	ns	ns	ns	ns	ns	ns
SS052MW592	7/11/2002	<0.001	<0.001	<0.001	<0.001	0.00755	0.00201	0.00195
SS052MW592	4/7/2003	<0.001	<0.001	<0.001	<0.001	0.00887	0.00191	0.00319
SS052MW592	4/8/2004	0.00008 J	0.00038 J	<0.001	<0.001	0.00603	0.00102	0.00265
SS052MW592	4/1/2005	<0.001	<0.001	<0.001	<0.001	0.0244	0.0047	0.0103
SS052MW592	5/30/2006	<0.00015	<0.00016	<0.00035	<0.00037	0.021	0.0061	0.0078
SS052MW592	4/18/2007	na	na	na	na	0.0087	0.004 J	0.0031
SS052MW592	4/7/2008	na	na	na	na	0.012	0.0056	0.0056
SS052MW592	4/17/2009	na	na	na	na	0.01	0.00943	0.00521
SS052MW594	6/6/2001	ns	ns	ns	ns	ns	ns	ns
SS052MW594	7/11/2002	<0.001	<0.001	<0.001	<0.001	0.00446	0.00084 J	0.0007 J
SS052MW594	4/7/2003	<0.001	<0.001	<0.001	<0.001	0.0191	0.00845	0.00522
SS052MW594	4/9/2004	0.00011 J	<0.001	<0.001	<0.001	0.00996	0.0035	0.00334
SS052MW594	4/1/2005	<0.001	<0.001	<0.001	<0.001	0.0187	0.00799	0.00665
SS052MW594	5/30/2006	<0.00015	<0.00016	<0.00035	<0.00037	0.0116	0.0102	0.0035
SS052MW594	5/8/2007	na	na	na	na	0.0046	0.0048	0.0016 J
SS052MW594	4/9/2008	na	na	na	na	0.0087	0.0074	0.0035
SS052MW594	4/20/2009	na	na	na	na	0.00519	0.00871	0.00199 J

Notes:

1. J = analyte detected at reported concentration; quantitation is an estimate
2. na = not analyzed. ns = not sampled during this sampling period.
3. See Figure 7 for well locations.

TABLE 10
DATA NEEDS SUMMARY

<table>
<tr><th rowspan="2">PRELIMINARY CONCEPTUAL SITE MODEL POTENTIAL EXPOSURE ROUTE</th><th rowspan="2">DATA NEEDS</th><th colspan="3">APPROACH TO FILL DATA NEED</th></tr>
<tr><th>EXISTING DATA REVIEWED</th><th>REMEDIAL INVESTIGATION ACTIVITY</th><th>INVESTIGATION METHODS AND INITIAL NUMBER OF SAMPLES</th></tr>
<tr><td>On-site exposure to on-site soil via direct contact and ingestion.</td><td>Volatile organic compound (VOC), Semi-volatile organic compound (SVOC), total petroleum hydrocarbon (TPH) and metals concentrations in Site surface and subsurface soil. Geotechnical properties of Site soil.</td><td>Existing Site soil data.</td><td>Investigate lateral and vertical extent of VOC, SVOC, TPH and metals concentrations in Site surface and subsurface soil samples relative to pathway-based screening criteria. Collect samples for geotechnical testing.</td><td rowspan="3">• Drill 14 on-site soil borings to top of unweathered Navarro Shale. Sample continuously for lithologic purposes.
• Collect three soil samples from each boring for laboratory analysis (from 0-0.5 ft. depth interval: from within 0.5-4.0 ft. range; and below 5 ft. within vadose zone based on field conditions).
• Pending soil boring findings, excavate one or more test pits near Site boundary. Depending on soil conditions observed, collect one or more samples for laboratory analyses.
• Analyze soil samples for VOCs, SVOCs, TPH, metals, and moisture content.
• Analyze selected representative samples for potential fate and transport parameters (total organic carbon, bulk density, air-filled porosity, water-filled porosity, air permeability).
• Install 9 on-site soil gas sampling points and analyze soil vapors for VOCs.
• Install 3 subslab vapor sample points at the former office building located at the Site.</td></tr>
<tr><td>On-site human receptor inhalation of vapors that have migrated from subsurface soil through the soil pore space and into indoor/ambient air.</td><td>VOC concentrations in Site subsurface soil.</td><td>Existing Site soil data.</td><td>Investigate lateral extent of VOCs in subsurface soil samples relative to pathway-based screening criteria. Evaluate soil properties relative to potential vapor transport.</td></tr>
<tr><td>On-site and off-site human receptor inhalation of particulates in ambient air resulting from fugitive dust generation and/or human contact with/ingestion of particles deposited on Site surface soil.</td><td>SVOC, TPH and metals concentrations in Site surface soil.</td><td>Existing soil data and Site setting/vegetative cover information.</td><td>Investigate lateral extent of SVOC, TPH and metals concentrations in Site surface soil.</td></tr>
</table>

TABLE 10
DATA NEEDS SUMMARY

PRELIMINARY CONCEPTUAL SITE MODEL POTENTIAL EXPOSURE ROUTE	DATA NEEDS	APPROACH TO FILL DATA NEED		
		EXISTING DATA REVIEWED	REMEDIAL INVESTIGATION ACTIVITY	INVESTIGATION METHODS AND INITIAL NUMBER OF SAMPLES
On-site human receptor inhalation of vapors that have migrated from NAPL and/or groundwater through the soil pore space and into on-site indoor/ambient air.	VOC and TPH concentrations in Site groundwater and LNAPL. Location and extent of NAPL. Groundwater flow rate and direction in affected water-bearing unit. BTEX natural attenuation potential. COPC concentrations in Site soil gas and subslab space.	Existing Site groundwater and LNAPL chemistry data. Existing groundwater flow rate and direction information. Existing LNAPL extent and thickness information.	Investigate lateral extent and thickness of NAPL on-site. Evaluate VOC and TPH concentrations in LNAPL. Investigate lateral extent of VOCs in Site groundwater relative to pathway-based screening criteria. Evaluate affected water-bearing unit hydraulic characteristics. Assess BTEX natural attenuation potential through evaluation of multiple lines of evidence (temporal trends, geochemical conditions, etc.). Install soil gas probes to evaluate concentrations of COPCs in pore space within vadose zone. Collect subslab vapor samples at former office building.	• Install 9 permanent on-site groundwater monitoring wells. • Install 5 permanent on-site NAPL monitoring wells. • Gauge all new and previous on-site wells for possible presence of NAPL and measure water levels. • Collect two representative LNAPL samples and analyze for VOCs and TPH. • Collect groundwater samples from existing and new on-site groundwater monitoring wells if LNAPL is not present. Measure temperature, specific conductance, pH, dissolved oxygen (DO) and oxidation-reduction potential (ORP) during purging. • Analyze groundwater samples for VOCs • Analyze groundwater samples for SVOCs, TPH and metals (as EPA has specified). • Analyze groundwater samples for indicators of natural attenuation (nitrate, nitrite, sulfate, and ferrous iron). • Perform hydraulic testing (slug tests) on selected monitoring wells. • Perform second NAPL gauging, water level measurement and groundwater sampling event. • Install 9 on-site soil gas sampling points and analyze soil vapors for VOCs. • Install 3 subslab sample points at the former office building located at the Site.

TABLE 10
DATA NEEDS SUMMARY

PRELIMINARY CONCEPTUAL SITE MODEL POTENTIAL EXPOSURE ROUTE	DATA NEEDS	APPROACH TO FILL DATA NEED		
		EXISTING DATA REVIEWED	REMEDIAL INVESTIGATION ACTIVITY	INVESTIGATION METHODS AND INITIAL NUMBER OF SAMPLES
Off-site human receptor inhalation of vapors that have migrated from groundwater through the soil pore space and into off-site ambient/indoor air.	VOC concentrations in off-site groundwater. Groundwater flow rate and direction in affected water-bearing unit off-site. BTEX natural attenuation potential.	Existing groundwater and LNAPL chemistry data. Existing groundwater flow rate and direction information.	Investigate lateral extent of VOCs in off-site groundwater relative to pathway-based screening criteria. Assess BTEX natural attenuation potential through evaluation of multiple lines of evidence (temporal trends, geochemical conditions, etc.).	• Install 5 permanent off-site groundwater monitoring wells. • Measure water levels in all new off-site wells for possible presence of NAPL. • Collect groundwater samples from new off-site groundwater wells. Measure temperature, specific conductance, pH, DO and ORP during purging. • Analyze groundwater samples for VOCs. • Analyze groundwater samples for SVOCs, TPH and metals (as EPA has specified). • Analyze groundwater samples for indicators of natural attenuation (nitrate, nitrite, sulfate, and ferrous iron). • Perform second water level measurement and groundwater sampling event.
Mammalian and avian exposure via ingestion of Site COPCs that may have migrated to off-site ditch surface water via rainfall runoff from the Site.	COPC concentrations in ditch surface water adjacent to and upstream of Site.	Existing data regarding ephemeral nature of ditch. Ditch conditions observed during previous Site visits.	Collect ditch surface water samples (adjacent to and upstream of Site) and evaluate relative to screening levels for target receptors.	• Collect three ditch surface water samples adjacent to the Site and one or more upstream surface water samples. • Analyze surface water samples for VOCs, SVOCs and metals.

TABLE 10
DATA NEEDS SUMMARY

PRELIMINARY CONCEPTUAL SITE MODEL POTENTIAL EXPOSURE ROUTE	DATA NEEDS	APPROACH TO FILL DATA NEED		
		EXISTING DATA REVIEWED	REMEDIAL INVESTIGATION ACTIVITY	INVESTIGATION METHODS AND INITIAL NUMBER OF SAMPLES
Feasibility Study Data Need	Geotechnical properties of Site soils with regard to potential capping remedial action alternatives.	Existing soil data.	Test representative samples of each general soil type for relevant geotechnical parameters.	• Collect a representative sample of each general soil type and test for swell or settlement potential, one-dimensional consolidation, and compaction characteristics. • Collect three representative samples of each general soil type and test for grain-size distribution, and Atterberg Limits (fine-grained soils only).
Feasibility Study Data Need	Physical properties of LNAPL with regard to potential LNAPL recovery remedial action alternatives.	Existing LNAPL data.	Test representative LNAPL samples for relevant physical properties. Evaluate LNAPL recoverability.	• Collect two representative LNAPL samples and test for dynamic viscosity, density, air/LNAPL interfacial tension, and LNAPL/water interfacial tension (assuming sufficient LNAPL sample volumes can be obtained). • Perform LNAPL recoverability testing on selected well(s) where LNAPL is present.

TABLE 11 - PROPOSED SOIL SCREENING AND EXTENT EVALUATION VALUES

Chemicals of Interest	Laboratory Method Detection Limit[1] (mg/Kg)	Laboratory Reporting Limit[1] (mg/Kg)	Preliminary Screening Values: EPA Residential Soil Screening Criteria[2] (mg/Kg)	Preliminary Screening Values: $^{Tot}Soil_{Comb}$[5] (mg/Kg)	Preliminary Screening Values: $^{Air}Soil_{Inh-V}$[6] (mg/Kg)	Screening Value[7] (mg/Kg)	Potential Background Values: TCEQ[4] (mg/Kg)	Potential Background Values: Kelly AFB[8] (mg/Kg)	Extent Evaluation Comparison Value (mg/Kg)
METALS									
Aluminum	0.29965	25	7.7E+04	6.4E+04	--	6.4E+04	3.0E+04	--	6.4E+04
Arsenic	0.21793	1	2.2E+01	2.4E+01		2.2E+01	5.9E+00	6.3E+00	2.2E+01
Barium	0.01132	1	1.5E+04	7.8E+03	--	7.8E+03	3.0E+02	1.5E+02	7.8E+03
Chromium	0.05061	0.5	--	2.7E+04	--	2.7E+04	3.0E+01	4.3E+01	2.7E+04
Cobalt	0.06762	0.5	2.3E+01	2.1E+01	--	2.1E+01	7.0E+00	9.9E+00	2.1E+01
Copper	0.17370	0.5	3.1E+03	5.5E+02	--	5.5E+02	1.5E+01	3.0E+01	5.5E+02
Lead	0.10483	0.5	4.0E+02	5.0E+02	--	4.0E+02	1.5E+01	3.3E+01	4.0E+02
Manganese	0.03811	1.5	1.8E+03	3.4E+03	--	1.8E+03	3.0E+02	5.1E+02	1.8E+03
Mercury	0.05000	0.5	5.6E+00	2.1E+00	2.4E+00	2.1E+00	4.0E-02	--	2.1E+00
Nickel	0.11660	1	1.6E+03	8.3E+02	--	8.3E+02	1.0E+01	2.3E+01	8.3E+02
Selenium	0.23888	2	3.9E+02	3.1E+02	--	3.1E+02	3.0E-01	--	3.1E+02
Thallium	0.27699	1.5	--	6.3E+00	--	6.3E+00	9.3E+00	5.1E-01	9.3E+00
Vanadium	0.07907	0.5	5.5E+00	2.9E+00	--	2.9E+00	5.0E+01	5.7E+01	5.7E+01
Zinc	0.10843	1.5	2.4E+04	9.9E+03	--	9.9E+03	3.0E+01	7.3E+01	9.9E+03
VOCs									
1,1,1,2-Tetrachloroethane	0.00140	0.005	2.4E+03	3.9E+01	4.7E+01	3.9E+01	---	--	3.9E+01
1,1,1-Trichloroethane	0.00074	0.005	8.7E+03	3.2E+04	3.9E+04	8.7E+03	---	--	8.7E+03
1,1,2,2-Tetrachloroethane	0.00087	0.005	3.1E+02	4.0E+00	4.6E+00	4.0E+00	---	--	4.0E+00
1,1,2-Trichloroethane	0.00073	0.005	3.1E+02	1.0E+01	1.2E+01	1.0E+01	---	--	1.0E+01
1,1-Dichloroethane	0.00087	0.005	1.6E+04	2.6E+03	3.2E+03	2.6E+03	---	--	2.6E+03
1,1-Dichloroethene	0.00122	0.01	2.4E+02	1.6E+03	2.7E+03	2.4E+02	---	--	2.4E+02
1,1-Dichloropropene	0.00065	0.005	--	2.6E+01	4.6E+01	2.6E+01	---	--	2.6E+01
1,2,3-Trichloropropane	0.00131	0.005	5.2E+00	2.0E-01	9.6E+01	2.0E-01	---	--	2.0E-01
1,2,4-Trichlorobenzene	0.00197	0.005	6.2E+01	7.0E+01	7.8E+01	6.2E+01	---	--	6.2E+01
1,2,4-Trimethylbenzene	0.00092	0.005	6.2E+01	7.3E+01	8.1E+01	6.2E+01	---	--	6.2E+01
1,2-Dibromo-3-chloropropane	0.00244	0.005	4.9E+00	8.0E-02	8.1E-02	8.0E-02	---	--	8.0E-02
1,2-Dibromoethane	0.00102	0.01	7.8E+01	4.3E-01	5.0E-01	4.3E-01	---	--	4.3E-01
1,2-Dichlorobenzene	0.00080	0.005	1.9E+03	3.9E+02	4.1E+02	3.9E+02	---	--	3.9E+02
1,2-Dichloroethane	0.00090	0.005	1.4E+03	6.4E+00	7.1E+00	6.4E+00	---	--	6.4E+00
1,2-Dichloropropane	0.00071	0.005	1.6E+01	3.1E+01	3.2E+01	1.6E+01	---	--	1.6E+01
1,3,5-Trimethylbenzene	0.00090	0.005	7.8E+02	5.9E+01	6.0E+01	5.9E+01	---	--	5.9E+01
1,3-Dichlorobenzene	0.00071	0.005	--	6.2E+01	6.3E+01	6.2E+01	---	--	6.2E+01
1,3-Dichloropropane	0.00063	0.005	1.6E+03	2.6E+01	4.6E+01	2.6E+01	---	--	2.6E+01
1,4-Dichlorobenzene	0.00066	0.005	3.5E+03	2.5E+02	1.3E+03	2.5E+02	---	--	2.5E+02
2,2-Dichloropropane	0.00182	0.005	--	3.1E+01	3.2E+01	3.1E+01	---	--	3.1E+01
2-Butanone	0.00190	0.01	2.8E+04	2.7E+04	5.9E+04	2.7E+04	---	--	2.7E+04
2-Chlorotoluene	0.00068	0.005	1.6E+03	8.3E+02	2.2E+03	8.3E+02	---	--	8.3E+02
2-Hexanone	0.00101	0.01	2.1E+02	2.1E+02	4.2E+02	2.1E+02	---	--	2.1E+02

TABLE 11 - PROPOSED SOIL SCREENING AND EXTENT EVALUATION VALUES

Chemicals of Interest	Laboratory Method Detection Limit[1] (mg/Kg)	Laboratory Reporting Limit[1] (mg/Kg)	Preliminary Screening Values: EPA Residential Soil Screening Criteria[2] (mg/Kg)	Preliminary Screening Values: $^{Tot}Soil_{Comb}$[5] (mg/Kg)	Preliminary Screening Values: $^{Air}Soil_{Inh-V}$[6] (mg/Kg)	Screening Value[7] (mg/Kg)	Potential Background Values: TCEQ[4] (mg/Kg)	Potential Background Values: Kelly AFB[8] (mg/Kg)	Extent Evaluation Comparison Value (mg/Kg)
4-Chlorotoluene	0.00083	0.005	5.5E+03	2.5E+00	2.5E+00	2.5E+00	---	--	2.5E+00
4-Methyl-2-pentanone	0.00147	0.01	5.3E+03	5.4E+03	3.0E+04	5.3E+03	---	--	5.3E+03
Acetone	0.00166	0.01	6.1E+04	5.4E+03	5.8E+03	5.4E+03	---	--	5.4E+03
Benzene	0.00063	0.005	8.6E+01	4.8E+01	8.4E+01	4.8E+01	---	--	4.8E+01
Bromobenzene	0.00099	0.005	3.0E+02	2.8E+02	5.0E+02	2.8E+02	---	--	2.8E+02
Bromodichloromethane	0.00066	0.005	1.6E+03	9.8E+01	--	9.8E+01	---	--	9.8E+01
Bromoform	0.00137	0.005	1.2E+03	2.8E+02	4.3E+02	2.8E+02	---	--	2.8E+02
Bromomethane	0.00083	0.01	7.3E+00	2.9E+01	3.9E+01	7.3E+00	---	--	7.3E+00
Carbon disulfide	0.00055	0.01	8.2E+02	3.3E+03	5.5E+03	8.2E+02	---	--	8.2E+02
Carbon tetrachloride	0.00113	0.005	4.7E+01	9.7E+00	1.2E+01	9.7E+00	---	--	9.7E+00
Chlorobenzene	0.00096	0.005	2.9E+02	3.2E+02	3.9E+02	2.9E+02	---	--	2.9E+02
Chloroethane	0.00140	0.01	1.5E+04	2.3E+04	7.9E+04	1.5E+04	---	--	1.5E+04
Chloroform	0.00066	0.005	2.1E+02	8.0E+00	8.0E+00	8.0E+00	---	--	8.0E+00
Chloromethane	0.00166	0.01	1.2E+02	8.4E+01	1.0E+02	8.4E+01	---	--	8.4E+01
cis-1,2-Dichloroethene	0.00318	0.005	7.8E+02	7.2E+02	6.3E+03	7.2E+02	---	--	7.2E+02
cis-1,3-Dichloropropene	0.00054	0.005	--	7.1E+00	5.3E+01	7.1E+00	---	--	7.1E+00
Dibromochloromethane (chlorodibron	0.00094	0.005	1.2E+03	7.2E+01	--	7.2E+01	---	--	7.2E+01
Dibromomethane	0.00075	0.005	2.5E+01	1.4E+02	1.4E+02	2.5E+01	---	--	2.5E+01
Dichlorodifluoromethane	0.00154	0.005	1.8E+02	1.2E+04	3.9E+04	1.8E+02	---	--	1.8E+02
Ethylbenzene	0.00102	0.005	3.5E+03	4.0E+03	7.9E+03	3.5E+03	---	--	3.5E+03
Hexachlorobutadiene	0.00113	0.005	6.1E+01	1.2E+01	1.5E+01	1.2E+01	---	--	1.2E+01
Isopropylbenzene (Cumene)	0.00092	0.005	2.1E+03	3.0E+03	4.8E+03	2.1E+03	---	--	2.1E+03
Methyl iodide (iodomethane)	0.00250	0.005	--	5.2E+01	9.5E+01	5.2E+01	---	--	5.2E+01
Methylene chloride	0.00219	0.01	1.7E+03	2.6E+02	3.9E+02	2.6E+02	---	--	2.6E+02
Naphthalene	0.00237	0.01	1.4E+02	1.2E+02	1.4E+02	1.2E+02	---	--	1.2E+02
n-Butylbenzene	0.00058	0.005	--	1.5E+03	3.4E+03	1.5E+03	---	--	1.5E+03
n-Propylbenzene	0.00095	0.005	3.4E+03	1.6E+03	3.3E+03	1.6E+03	---	--	1.6E+03
p-Isopropyltoluene	0.00102	0.005	--	2.5E+03	3.5E+03	2.5E+03	---	--	2.5E+03
sec-Butylbenzene	0.00070	0.005	--	1.6E+03	2.9E+03	1.6E+03	---	--	1.6E+03
Styrene	0.00071	0.005	6.3E+03	4.3E+03	5.8E+03	4.3E+03	---	--	4.3E+03
tert-Butyl methyl ether (MTBE)	0.00183	0.005	1.7E+04	5.9E+02	7.1E+02	5.9E+02	---	--	5.9E+02
tert-Butylbenzene	0.00095	0.005	--	1.4E+03	2.4E+03	1.4E+03	---	--	1.4E+03
Tetrachloroethene	0.00071	0.005	3.7E+02	9.4E+01	4.8E+02	9.4E+01	---	--	9.4E+01
Toluene	0.00138	0.005	5.0E+03	5.4E+03	3.2E+04	5.0E+03	---	--	5.0E+03
trans-1,2-Dichloroethene	0.00114	0.005	1.5E+02	3.7E+02	4.7E+02	1.5E+02	---	--	1.5E+02
trans-1,3-Dichloropropene	0.00058	0.005	--	2.6E+01	4.6E+01	2.6E+01	---	--	2.6E+01
Trichloroethene	0.00140	0.005	--	6.8E+01	7.9E+01	6.8E+01	---	--	6.8E+01
Trichlorofluoromethane	0.00066	0.005	7.9E+02	1.2E+04	2.2E+04	7.9E+02	---	--	7.9E+02
Vinyl chloride	0.00090	0.005	7.4E+01	3.4E+00	2.2E+01	3.4E+00	---	--	3.4E+00

TABLE 11 - PROPOSED SOIL SCREENING AND EXTENT EVALUATION VALUES

Chemicals of Interest	Laboratory Method Detection Limit[1] (mg/Kg)	Laboratory Reporting Limit[1] (mg/Kg)	Preliminary Screening Values: EPA Residential Soil Screening Criteria[2] (mg/Kg)	Preliminary Screening Values: $^{Tot}Soil_{Comb}$[5] (mg/Kg)	Preliminary Screening Values: $^{Air}Soil_{Inh\text{-}V}$[6] (mg/Kg)	Screening Value[7] (mg/Kg)	Potential Background Values: TCEQ[4] (mg/Kg)	Potential Background Values: Kelly AFB[8] (mg/Kg)	Extent Evaluation Comparison Value (mg/Kg)
Xylenes (total)	0.00113	0.005	6.3E+02	3.7E+03	4.8E+03	6.3E+02	---	--	6.3E+02
SVOCs									
2,4,5-Trichlorophenol	0.06208	0.33	6.1E+03	4.1E+03	1.1E+04	4.1E+03	---	--	4.1E+03
2,4,6-Trichlorophenol	0.00268	0.33	6.1E+01	6.7E+01	1.0E+03	6.1E+01	---	--	6.1E+01
2,4-Dichlorophenol	0.18000	0.33	1.8E+02	1.9E+02	6.8E+03	1.8E+02	---	--	1.8E+02
2,4-Dimethylphenol	0.06360	0.33	1.2E+03	8.8E+02	2.6E+03	8.8E+02	---	--	8.8E+02
2,4-Dinitrophenol	0.12800	1.6	1.2E+02	1.3E+02	--	1.2E+02	---	--	1.2E+02
2,4-Dinitrotoluene	0.03290	0.33	1.2E+02	6.9E+00	1.5E+01	6.9E+00	---	--	6.9E+00
2,6-Dinitrotoluene	0.20900	0.33	6.1E+01	6.9E+00	2.2E+01	6.9E+00	---	--	6.9E+00
2-Chloronaphthalene	0.21500	0.33	6.3E+03	5.0E+03	--	5.0E+03	---	--	5.0E+03
2-Chlorophenol	0.02330	0.33	3.9E+02	3.6E+02	3.2E+03	3.6E+02	---	--	3.6E+02
2-Methylnaphthalene	0.18900	0.33	3.1E+02	2.5E+02	--	2.5E+02	---	--	2.5E+02
2-Nitroaniline	0.19500	0.33	6.1E+02	1.1E+01	2.4E+01	1.1E+01	---	--	1.1E+01
2-Nitrophenol	0.18000	0.33	--	1.0E+02	4.1E+02	1.0E+02	---	--	1.0E+02
3,3'-Dichlorobenzidine	0.06400	1.6	--	1.0E+01	--	1.0E+01	---	--	1.0E+01
3-Nitroaniline	0.21200	0.33	--	1.9E+01	4.6E+02	1.9E+01	---	--	1.9E+01
4,6-Dinitro-2-methylphenol	0.20700	1.6	6.1E+00	5.2E+00	2.4E+01	5.2E+00	---	--	5.2E+00
4-Bromophenyl phenyl ether	0.20000	0.33	--	2.7E-01	5.0E+00	2.7E-01	---	--	2.7E-01
4-Chloro-3-methylphenol	0.19200	0.33	6.1E+03	3.3E+02	1.8E+04	3.3E+02	---	--	3.3E+02
4-Chloroaniline	0.06600	0.33	2.4E+02	2.3E+01	7.4E+02	2.3E+01	---	--	2.3E+01
4-Chlorophenyl phenyl ether	0.19800	0.33	--	1.5E-01	1.3E+00	1.5E-01	---	--	1.5E-01
Cresol, p- (4-methylphenol)	0.00279	0.33	3.1E+02	2.7E+02	1.5E+03	2.7E+02	---	--	2.7E+02
4-Nitroaniline	0.18000	1.6	2.4E+02	1.9E+02	6.2E+02	1.9E+02	---	--	1.9E+02
4-Nitrophenol	0.18000	1.6	--	5.1E+01	8.3E+01	5.1E+01	---	--	5.1E+01
Acenaphthene	0.18900	0.33	3.4E+03	3.0E+03	--	3.0E+03	---	--	3.0E+03
Acenaphthylene	0.19200	0.33	--	3.8E+03	--	3.8E+03	---	--	3.8E+03
Aniline	0.05100	0.33	4.3E+02	5.9E+01	6.7E+01	5.9E+01	---	--	5.9E+01
Anthracene	0.20700	0.33	1.7E+04	1.8E+04	--	1.7E+04	---	--	1.7E+04
Benzo(a)anthracene	0.20730	0.33	--	5.6E+00	1.9E+03	5.6E+00	---	--	5.6E+00
Benzo(a)pyrene	0.18511	0.33	--	5.6E-01	4.4E+02	5.6E-01	---	--	5.6E-01
Benzo(b)fluoranthene	0.01934	0.33	--	5.7E+00	3.2E+03	5.7E+00	---	--	5.7E+00
Benzo(g,h,i)perylene	0.17530	0.33	--	1.8E+03	--	1.8E+03	---	--	1.8E+03
Benzo(k)fluoranthene	0.02941	0.33	--	5.7E+01	7.8E+04	5.7E+01	---	--	5.7E+01
Benzyl alcohol	0.12730	0.33	6.1E+03	2.7E+03	4.6E+03	2.7E+03	---	--	2.7E+03
Bis(2-Chloroethoxy)methane	0.18600	0.33	1.8E+02	2.5E+00	5.8E+00	2.5E+00	---	--	2.5E+00
Bis(2-Chloroethyl)ether	0.03298	0.33	--	1.4E+00	1.8E+00	1.4E+00	---	--	1.4E+00
Bis(2-Chloroisopropyl)ether	0.00884	0.33	3.1E+03	4.1E+01	1.1E+02	4.1E+01	---	--	4.1E+01
Bis(2-Ethylhexyl)phthalate	0.20004	0.33	1.2E+03	4.3E+01	--	4.3E+01	---	--	4.3E+01
Butyl benzyl phthalate	0.20070	0.33	1.2E+04	1.6E+03	1.3E+04	1.6E+03	---	--	1.6E+03

TABLE 11 - PROPOSED SOIL SCREENING AND EXTENT EVALUATION VALUES

Chemicals of Interest	Laboratory Method Detection Limit[1] (mg/Kg)	Laboratory Reporting Limit[1] (mg/Kg)	Preliminary Screening Values: EPA Residential Soil Screening Criteria[2] (mg/Kg)	Preliminary Screening Values: $^{Tot}Soil_{Comb}$[5] (mg/Kg)	Preliminary Screening Values: $^{Air}Soil_{Inh-V}$[6] (mg/Kg)	Screening Value[7] (mg/Kg)	Potential Background Values: TCEQ[4] (mg/Kg)	Potential Background Values: Kelly AFB[8] (mg/Kg)	Extent Evaluation Comparison Value (mg/Kg)
Chrysene	0.20173	0.33	--	5.6E+02	3.0E+05	5.6E+02	---	--	5.6E+02
Dibenz(a,h)anthracene	0.18983	0.33	--	5.5E-01	1.0E+03	5.5E-01	---	--	5.5E-01
Dibenzofuran	0.19669	0.33	7.8E+01	2.7E+02	--	7.8E+01	---	--	7.8E+01
Diethyl phthalate	0.20413	0.33	4.9E+04	1.4E+03	1.5E+03	1.4E+03	---	--	1.4E+03
Dimethyl phthalate	0.19970	0.33	--	6.6E+02	6.7E+02	6.6E+02	---	--	6.6E+02
Di-n-butyl phthalate	0.21297	0.33	6.1E+03	4.4E+03	1.5E+04	4.4E+03	---	--	4.4E+03
Di-n-octyl phthalate	0.21357	0.33	--	1.3E+03	2.8E+05	1.3E+03	---	--	1.3E+03
Fluoranthene	0.21082	0.33	2.3E+03	2.3E+03	--	2.3E+03	---	--	2.3E+03
Fluorene	0.20319	0.33	2.3E+03	2.3E+03	--	2.3E+03	---	--	2.3E+03
Hexachlorobenzene	0.20812	0.33	4.9E+01	1.0E+00	9.8E+00	1.0E+00	---	--	1.0E+00
Hexachlorocyclopentadiene	0.02227	0.33	3.7E+02	7.2E+00	7.3E+00	7.2E+00	---	--	7.2E+00
Hexachloroethane	0.02991	0.33	6.1E+01	6.7E+01	5.0E+02	6.1E+01	---	--	6.1E+01
Indeno(1,2,3-cd)pyrene	0.18100	0.33	--	5.7E+00	1.3E+04	5.7E+00	---	--	5.7E+00
Isophorone	0.19387	0.33	1.2E+04	1.2E+03	1.4E+03	1.2E+03	---	--	1.2E+03
Nitrobenzene	0.04740	0.33	1.3E+02	3.4E+01	3.4E+01	3.4E+01	---	--	3.4E+01
n-Nitrosodi-n-propylamine	0.02859	0.33	--	4.0E-01	--	4.0E-01	---	--	4.0E-01
Pentachlorophenol	0.02212	1.6	1.4E+03	2.4E+00	2.3E+02	2.4E+00	---	--	2.4E+00
Phenanthrene	0.20300	0.33	--	1.7E+03	--	1.7E+03	---	--	1.7E+03
Phenol	0.03736	0.33	1.8E+04	1.6E+03	1.7E+03	1.6E+03	---	--	1.6E+03
Pyrene	0.22085	0.33	1.7E+03	1.7E+03	--	1.7E+03	---	--	1.7E+03

Notes:

1. Method Detection Limit and Reporting Limit provided by Test America Laboratory, Houston, Texas.
2. EPA Screening Values from the EPA Generic Tables for Screening Levels, Residential Soil Supporting, updated December 2009.
3. TCEQ Protective Concentration Levels are the Tier 1 values for residential soils and a 30-acre source area, updated March 31, 2010.
4. TCEQ Background concentrations from Figure 30 TAC 350.51(m).
5. $^{Tot}Soil_{Comb}$ PCL = TCEQ Protective Concentration Level for 30 acre source area Residential total soil combined pathway (includes inhalation; ingestion; dermal pathways).
6. $^{Air}Soil_{Inh-V}$ PCL = TCEQ Protective Concentration Level for 30 acre source area Commercial/Industrial soil-to-air pathway (inhalation of volatiles and particulates).
7. The Screening Value is the lower value of the EPA Screening Level or TCEQ PCL.
8. Kelly AFB Background concentration values from "Final Report, Addendum to Final Background Levels of Inorganics in Soils at Kelly AFB", October 1999, upper tolerance limit values for the uppermost lithologic layer (black clay) used.

TABLE 12 - PROPOSED GROUNDWATER SCREENING AND EXTENT EVALUATION VALUES

Chemicals of Interest	Laboratory Method Detection Limit[1] (mg/L)	Laboratory Reporting Limit[1] (mg/L)	Preliminary Screening Values: TCEQ Protective Concentration Levels[2] $^{GW}GW_{Ing}$ (mg/L)	Preliminary Screening Values: US EPA Vapor Intrusion Generic Evaluation Values[3] 10^{-6} risk (mg/L)	Screening Value (mg/L)	Extent Evaluation Comparison Value (mg/L)
METALS						
Aluminum	0.00599	0.5	2.4E+01	--	2.4E+01	2.4E+01
Arsenic	0.00328	0.01	1.0E-02	--	1.0E-02	1.0E-02
Barium	0.0016	0.02	2.0E+00	--	2.0E+00	2.0E+00
Chromium	0.00155	0.01	1.0E-01	--	1.0E-01	1.0E-01
Cobalt	0.00063	0.01	7.3E-03	--	7.3E-03	7.3E-03
Copper	0.00145	0.01	1.3E+00	--	1.3E+00	1.3E+00
Lead	0.0029	0.01	1.5E-02	--	1.5E-02	1.5E-02
Manganese	0.00084	0.01	1.1E+00	--	1.1E+00	1.1E+00
Mercury	0.00002	0.002	2.0E-03	6.8E-04	6.8E-04	6.8E-04
Nickel	0.00165	0.01	4.9E-01	--	4.9E-01	4.9E-01
Selenium	0.00417	0.04	5.0E-02	--	5.0E-02	5.0E-02
Thallium	0.00784	0.03	2.0E-03	--	2.0E-03	2.0E-03
Vanadium	0.00169	0.01	1.7E-03	--	1.7E-03	1.7E-03
Zinc	0.00217	0.03	7.3E+00	--	7.3E+00	7.3E+00
VOCs						
1,1,1,2-Tetrachloroethane	0.00009	0.001	3.5E-02	3.3E-03	3.3E-03	3.3E-03
1,1,1-Trichloroethane	0.00012	0.001	2.0E-01	3.1E+00	2.0E-01	2.0E-01
1,1,2,2-Tetrachloroethane	0.00016	0.001	4.6E-03	3.0E-03	3.0E-03	3.0E-03
1,1,2-Trichloroethane	0.00018	0.001	5.0E-03	5.0E-03	5.0E-03	5.0E-03
1,1-Dichloroethane	0.00016	0.001	4.9E+00	2.2E+00	2.2E+00	2.2E+00
1,1-Dichloroethene	0.00013	0.001	7.0E-03	1.9E-01	7.0E-03	7.0E-03
1,1-Dichloropropene	0.00013	0.001	9.1E-03	--	9.1E-03	9.1E-03
1,2,3-Trichloropropane	0.00011	0.001	3.0E-05	2.9E-01	3.0E-05	3.0E-05
1,2,4-Trichlorobenzene	0.00020	0.001	7.0E-02	3.4E+00	7.0E-02	7.0E-02
1,2,4-Trimethylbenzene	0.00010	0.001	2.4E-01	2.4E-02	2.4E-02	2.4E-02
1,2-Dibromo-3-chloropropane	0.00039	0.002	2.0E-04	3.3E-02	2.0E-04	2.0E-04
1,2-Dibromoethane	0.00018	0.002	5.0E-05	3.6E-04	5.0E-05	5.0E-05
1,2-Dichlorobenzene	0.0001	0.001	6.0E-01	2.6E+00	6.0E-01	6.0E-01
1,2-Dichloroethane	0.00013	0.001	5.0E-03	5.0E-03	5.0E-03	5.0E-03
1,2-Dichloropropane	0.00016	0.001	5.0E-03	3.5E-02	5.0E-03	5.0E-03
1,3,5-Trimethylbenzene	0.00008	0.001	1.2E+00	2.5E-02	2.5E-02	2.5E-02
1,3-Dichlorobenzene	0.00013	0.001	7.3E-01	8.3E-01	7.3E-01	7.3E-01
1,3-Dichloropropane	0.00012	0.001	9.1E-03	--	9.1E-03	9.1E-03
1,4-Dichlorobenzene	0.00005	0.001	7.5E-02	8.2E+00	7.5E-02	7.5E-02
2,2-Dichloropropane	0.00009	0.001	1.3E-02	--	1.3E-02	1.3E-02
2-Butanone	0.00076	0.002	1.5E+01	4.4E+02	1.5E+01	1.5E+01
2-Chlorotoluene	0.00017	0.001	4.9E-01	--	4.9E-01	4.9E-01
2-Hexanone	0.00031	0.002	1.2E-01	--	1.2E-01	1.2E-01
4-Chlorotoluene	0.00180	0.001	1.7E+00	--	1.7E+00	1.7E+00
4-Methyl-2-pentanone	0.00031	0.002	2.0E+00	1.4E+01	2.0E+00	2.0E+00
Acetone	0.002	0.002	2.2E+01	2.2E+02	2.2E+01	2.2E+01
Benzene	0.00013	0.001	5.0E-03	5.0E-03	5.0E-03	5.0E-03
Bromobenzene	0.00014	0.001	2.0E-01	--	2.0E-01	2.0E-01
Bromodichloromethane	0.00014	0.001	1.5E-02	2.1E-03	2.1E-03	2.1E-03
Bromoform	0.00012	0.001	1.2E-01	8.3E+00	1.2E-01	1.2E-01
Bromomethane	0.00022	0.002	3.4E-02	2.0E-02	2.0E-02	2.0E-02
Carbon disulfide	0.00007	0.002	2.4E+00	5.6E-01	5.6E-01	5.6E-01
Carbon tetrachloride	0.00013	0.001	5.0E-03	5.0E-03	5.0E-03	5.0E-03
Chlorobenzene	0.00011	0.001	1.0E-01	3.9E+00	1.0E-01	1.0E-01
Chloroethane	0.00019	0.002	9.8E+00	2.8E+01	9.8E+00	9.8E+00
Chloroform	0.00012	0.001	2.4E-01	8.0E-02	8.0E-02	8.0E-02

TABLE 12 - PROPOSED GROUNDWATER SCREENING AND EXTENT EVALUATION VALUES

Chemicals of Interest	Laboratory Method Detection Limit[1] (mg/L)	Laboratory Reporting Limit[1] (mg/L)	Preliminary Screening Values: TCEQ Protective Concentration Levels[2] $^{GW}GW_{Ing}$ (mg/L)	Preliminary Screening Values: US EPA Vapor Intrusion Generic Evaluation Values[3] 10^{-6} risk (mg/L)	Screening Value (mg/L)	Extent Evaluation Comparison Value (mg/L)
Chloromethane	0.00015	0.002	7.0E-02	6.7E-03	6.7E-03	6.7E-03
cis-1,2-Dichloroethene	0.00016	0.001	7.0E-02	2.1E-01	7.0E-02	7.0E-02
cis-1,3-Dichloropropene	0.00011	0.001	1.7E-03	--	1.7E-03	1.7E-03
Dibromochloromethane (chlorodibromomethane)	0.00045	0.001	1.1E-02	3.2E-03	3.2E-03	3.2E-03
Dibromomethane	0.00052	0.001	1.2E-01	--	1.2E-01	1.2E-01
Dichlorodifluoromethane	0.00014	0.001	4.9E+00	1.4E-02	1.4E-02	1.4E-02
Ethylbenzene	0.00013	0.001	7.0E-01	7.0E-01	7.0E-01	7.0E-01
Hexachlorobutadiene	0.00017	0.001	1.2E-02	3.3E-04	3.3E-04	3.3E-04
Isopropylbenzene (Cumene)	0.00006	0.001	2.4E+00	8.4E-03	8.4E-03	8.4E-03
Methyl iodide (iodomethane)	0.002	0.002	3.4E-02	--	3.4E-02	3.4E-02
Methylene chloride	0.00042	0.002	5.0E-03	5.8E-02	5.0E-03	5.0E-03
Naphthalene	0.00047	0.001	4.9E-01	1.5E-01	1.5E-01	1.5E-01
n-Butylbenzene	0.00009	0.001	9.8E-01	2.6E-01	2.6E-01	2.6E-01
n-Propylbenzene	0.00025	0.001	9.8E-01	3.2E-01	3.2E-01	3.2E-01
p-Isopropyltoluene	0.00100	0.001	2.4E+00	--	2.4E+00	2.4E+00
sec-Butylbenzene	0.00014	0.001	9.8E-01	2.5E-01	2.5E-01	2.5E-01
Styrene	0.00010	0.001	1.0E-01	8.9E+00	1.0E-01	1.0E-01
tert-Butyl methyl ether (MTBE)	0.00015	0.001	2.4E-01	1.2E+02	2.4E-01	2.4E-01
tert-Butylbenzene	0.00016	0.001	9.8E-01	2.9E-01	2.9E-01	2.9E-01
Tetrachloroethene	0.00008	0.001	5.0E-03	5.0E-03	5.0E-03	5.0E-03
Toluene	0.00014	0.001	1.0E+00	1.5E+00	1.0E+00	1.0E+00
trans-1,2-Dichloroethene	0.00012	0.001	1.0E-01	1.8E-01	1.0E-01	1.0E-01
trans-1,3-Dichloropropene	0.00011	0.001	9.1E-03	--	9.1E-03	9.1E-03
Trichloroethene	0.00013	0.001	5.0E-03	5.0E-03	5.0E-03	5.0E-03
Trichlorofluoromethane	0.00008	0.001	7.3E+00	1.8E-01	1.8E-01	1.8E-01
Vinyl chloride	0.00013	0.002	2.0E-03	2.0E-03	2.0E-03	2.0E-03
Xylenes (total)	0.00032	0.001	1.0E+01	--	1.0E+01	1.0E+01
SVOCs						
2,4,5-Trichlorophenol	0.00025	0.015	2.4E+00	--	2.4E+00	2.4E+00
2,4,6-Trichlorophenol	0.00018	0.015	2.4E-02	--	2.4E-02	2.4E-02
2,4-Dichlorophenol	0.00015	0.015	7.3E-02	--	7.3E-02	7.3E-02
2,4-Dimethylphenol	0.00031	0.015	4.9E-01	--	4.9E-01	4.9E-01
2,4-Dinitrophenol	0.00039	0.015	4.9E-02	--	4.9E-02	4.9E-02
2,4-Dinitrotoluene	0.00100	0.015	1.3E-03	--	1.3E-03	1.3E-03
2,6-Dinitrotoluene	0.00008	0.015	1.3E-03	--	1.3E-03	1.3E-03
2-Chloronaphthalene	0.00008	0.015	2.0E+00	--	2.0E+00	2.0E+00
2-Chlorophenol	0.00013	0.015	1.2E-01	1.1E+00	1.2E-01	1.2E-01
2-Methylnaphthalene	0.00007	0.015	9.8E-02	3.3E+00	9.8E-02	9.8E-02
2-Nitroaniline	0.00019	0.015	7.3E-03	--	7.3E-03	7.3E-03
2-Nitrophenol	0.00022	0.015	4.9E-02	--	4.9E-02	4.9E-02
3,3'-Dichlorobenzidine	0.00018	0.015	2.0E-03	--	2.0E-03	2.0E-03
3-Nitroaniline	0.00018	0.015	7.3E-03	--	7.3E-03	7.3E-03
4,6-Dinitro-2-methylphenol	0.00083	0.015	2.4E-03	--	2.4E-03	2.4E-03
4-Bromophenyl phenyl ether	0.00010	0.015	6.1E-05	--	6.1E-05	6.1E-05
4-Chloro-3-methylphenol	0.00017	0.015	1.2E-01	--	1.2E-01	1.2E-01
4-Chloroaniline	0.00021	0.015	4.6E-03	--	4.6E-03	4.6E-03
4-Chlorophenyl phenyl ether	0.00010	0.015	6.1E-05	--	6.1E-05	6.1E-05
Cresol, p- (4-methylphenol)	0.00011	0.015	1.2E-01	--	1.2E-01	1.2E-01
4-Nitroaniline	0.00025	0.015	4.6E-02	--	4.6E-02	4.6E-02
4-Nitrophenol	0.00056	0.015	4.9E-02		4.9E-02	4.9E-02
Acenaphthene	0.00007	0.015	1.5E+00	--	1.5E+00	1.5E+00
Acenaphthylene	0.00008	0.015	1.5E+00	--	1.5E+00	1.5E+00

TABLE 12 - PROPOSED GROUNDWATER SCREENING AND EXTENT EVALUATION VALUES

Chemicals of Interest	Laboratory Method Detection Limit[1] (mg/L)	Laboratory Reporting Limit[1] (mg/L)	Preliminary Screening Values: TCEQ Protective Concentration Levels[2] $^{GW}GW_{Ing}$ (mg/L)	Preliminary Screening Values: US EPA Vapor Intrusion Generic Evaluation Values[3] 10^{-6} risk (mg/L)	Screening Value (mg/L)	Extent Evaluation Comparison Value (mg/L)
Aniline	0.00008	0.015	1.6E-01	--	1.6E-01	1.6E-01
Anthracene	0.00007	0.015	7.3E+00	--	7.3E+00	7.3E+00
Benzo(a)anthracene	0.00012	0.015	1.3E-03	--	1.3E-03	1.3E-03
Benzo(a)pyrene	0.00008	0.015	2.0E-04	--	2.0E-04	2.0E-04
Benzo(b)fluoranthene	0.00016	0.015	1.3E-03	**	1.3E-03	1.3E-03
Benzo(g,h,i)perylene	0.00013	0.015	7.3E-01	--	7.3E-01	7.3E-01
Benzo(k)fluoranthene	0.00012	0.015	1.3E-02	--	1.3E-02	1.3E-02
Benzyl alcohol	0.00017	0.015	2.4E+00	--	2.4E+00	2.4E+00
Bis(2-Chloroethoxy)methane	0.00013	0.015	8.3E-04	--	8.3E-04	8.3E-04
Bis(2-Chloroethyl)ether	0.00015	0.015	8.3E-04	1.0E-02	8.3E-04	8.3E-04
Bis(2-Chloroisopropyl)ether[7]	0.0004	0.015	1.3E-02	5.1E-02	1.3E-02	1.3E-02
Bis(2-Ethylhexyl)phthalate	0.00037	0.015	6.0E-03	--	6.0E-03	6.0E-03
Butyl benzyl phthalate	0.00012	0.015	4.8E-01	--	4.8E-01	4.8E-01
Chrysene	0.00013	0.015	1.3E-01	**	1.3E-01	1.3E-01
Dibenz(a,h)anthracene	0.0005	0.015	2.0E-04	--	2.0E-04	2.0E-04
Dibenzofuran	0.00008	0.015	9.8E-02	**	9.8E-02	9.8E-02
Diethyl phthalate	0.00150	0.015	2.0E+01	--	2.0E+01	2.0E+01
Dimethyl phthalate	0.00007	0.015	2.0E+01	--	2.0E+01	2.0E+01
Di-n-butyl phthalate	0.00011	0.015	2.4E+00	--	2.4E+00	2.4E+00
Di-n-octyl phthalate	0.00016	0.015	4.9E-01	--	4.9E-01	4.9E-01
Fluoranthene	0.00008	0.015	9.8E-01	--	9.8E-01	9.8E-01
Fluorene	0.00007	0.015	9.8E-01	**	9.8E-01	9.8E-01
Hexachlorobenzene	0.00011	0.015	1.0E-03	1.0E-03	1.0E-03	1.0E-03
Hexachlorocyclopentadiene	0.00013	0.015	5.0E-02	5.0E-02	5.0E-02	5.0E-02
Hexachloroethane	0.0001	0.015	2.4E-02	3.8E-03	3.8E-03	3.8E-03
Indeno(1,2,3-cd)pyrene	0.0001	0.015	1.3E-03	--	1.3E-03	1.3E-03
Isophorone	0.00011	0.015	9.6E-01	--	9.6E-01	9.6E-01
Nitrobenzene	0.00011	0.015	4.9E-02	2.0E+00	4.9E-02	4.9E-02
n-Nitrosodi-n-propylamine	0.0001	0.015	1.3E-04	--	1.3E-04	1.3E-04
Pentachlorophenol	0.00061	0.015	1.0E-03	--	1.0E-03	1.0E-03
Phenanthrene	0.00009	0.015	7.3E-01	--	7.3E-01	7.3E-01
Phenol	0.00004	0.015	7.3E+00	--	7.3E+00	7.3E+00
Pyrene	0.00009	0.015	7.3E-01	**	7.3E-01	7.3E-01

Notes:

1. Method Detection Limit and Reporting Limit provided by Test America Laboratory, Houston, Texas.
2. TCEQ Protective Concentration Levels are the Tier 1 residential values for Class 1/2 groundwater (groundwater ingestion), updated March 31, 2010.
3. EPA Evaluation Values from "OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils", Table 2C, Generic Screening Levels and Summary Sheet, US EPA 2002.
4. -- = No evaluation value published.
5. ** Target soil gas concentration exceeds the maximum possible vapor concentration (pathway incomplete).

TABLE 13 - ECOLOGICAL SCREENING VALUES FOR SOIL

Chemicals of Interest	Laboratory Method Detection Limit [1] (mg/Kg)	Laboratory Reporting Limit[1] (mg/Kg)	TCEQ Ecological Benchmarks for Soil (mg/Kg) [2]	Notation [3]
METALS				
Aluminum	0.29965	25	5.0E+00	p
Arsenic	0.21793	1	1.8E+01	p
Barium	0.01132	1	3.3E+02	i
Chromium	0.05061	0.5	4.0E-01	i
Cobalt	0.06762	0.5	1.3E+01	p
Copper	0.17370	0.5	6.1E+01	i
Lead	0.10483	0.5	1.2E+02	p
Manganese	0.03811	1.5	5.0E+02	p
Mercury	0.05000	0.5	1.0E-01	i
Nickel	0.11660	1	3.0E+01	p
Selenium	0.23888	2	1.0E+00	p
Thallium	0.27699	1.5	1.0E+00	p
Vanadium	0.07907	0.5	2.0E+00	p
Zinc	0.10843	1.5	1.2E+02	i
VOCs				
1,1,1,2-Tetrachloroethane	0.00140	0.005		
1,1,1-Trichloroethane	0.00074	0.005		
1,1,2,2-Tetrachloroethane	0.00087	0.005		
1,1,2-Trichloroethane	0.00073	0.005		
1,1-Dichloroethane	0.00087	0.005		
1,1-Dichloroethene	0.00122	0.01		
1,1-Dichloropropene	0.00065	0.005		
1,2,3-Trichloropropane	0.00131	0.005		
1,2,4-Trichlorobenzene	0.00197	0.005	2.0E+01	i
1,2,4-Trimethylbenzene	0.00092	0.005		
1,2-Dibromo-3-chloropropane	0.00244	0.005		
1,2-Dibromoethane	0.00102	0.01		
1,2-Dichlorobenzene	0.00080	0.005		
1,2-Dichloroethane	0.00090	0.005		
1,2-Dichloropropane	0.00071	0.005	7.0E+02	i
1,3,5-Trimethylbenzene	0.00090	0.005		
1,3-Dichlorobenzene	0.00071	0.005		
1,3-Dichloropropane	0.00063	0.005		
1,4-Dichlorobenzene	0.00066	0.005	2.0E+01	i
2,2-Dichloropropane	0.00182	0.005		
2-Butanone	0.00190	0.01		
2-Chlorotoluene	0.00068	0.005		
2-Hexanone	0.00101	0.01		
4-Chlorotoluene	0.00083	0.005		
4-Methyl-2-pentanone	0.00147	0.01		
Acetone	0.00166	0.01		
Benzene	0.00063	0.005		
Bromobenzene	0.00099	0.005		
Bromodichloromethane	0.00066	0.005		
Bromoform	0.00137	0.005		
Bromomethane	0.00083	0.01		
Carbon disulfide	0.00055	0.01		

TABLE 13 - ECOLOGICAL SCREENING VALUES FOR SOIL

Chemicals of Interest	Laboratory Method Detection Limit [1] (mg/Kg)	Laboratory Reporting Limit[1] (mg/Kg)	TCEQ Ecological Benchmarks for Soil (mg/Kg) [2]	Notation [3]
Carbon tetrachloride	0.00113	0.005		
Chlorobenzene	0.00096	0.005	4.0E+01	i
Chloroethane	0.00140	0.01		
Chloroform	0.00066	0.005		
Chloromethane	0.00166	0.01		
cis-1,2-Dichloroethene	0.00318	0.005		
cis-1,3-Dichloropropene	0.00054	0.005		
Dibromochloromethane (chlorodibrom	0.00094	0.005		
Dibromomethane	0.00075	0.005		
Dichlorodifluoromethane	0.00154	0.005		
Ethylbenzene	0.00102	0.005		
Hexachlorobutadiene	0.00113	0.005		
Isopropylbenzene (Cumene)	0.00092	0.005		
Methyl iodide (iodomethane)	0.00250	0.005		
Methylene chloride	0.00219	0.01		
Naphthalene	0.00237	0.01		
n-Butylbenzene	0.00058	0.005		
n-Propylbenzene	0.00095	0.005		
p-Isopropyltoluene	0.00102	0.005		
sec-Butylbenzene	0.00070	0.005		
Styrene	0.00071	0.005	3.0E+02	p
tert-Butyl methyl ether (MTBE)	0.00183	0.005		
tert-Butylbenzene	0.00095	0.005		
Tetrachloroethene	0.00071	0.005		
Toluene	0.00138	0.005	2.0E+02	p
trans-1,2-Dichloroethene	0.00114	0.005		
trans-1,3-Dichloropropene	0.00058	0.005		
Trichloroethene	0.00140	0.005		
Trichlorofluoromethane	0.00066	0.005		
Vinyl chloride	0.00090	0.005		
Xylenes (total)	0.00113	0.005		
SVOCs				
2,4,5-Trichlorophenol	0.06208	0.33	4.0E+00	p
2,4,6-Trichlorophenol	0.00268	0.33	1.0E+01	i
2,4-Dichlorophenol	0.18000	0.33		
2,4-Dimethylphenol	0.06360	0.33		
2,4-Dinitrophenol	0.12800	1.6	2.0E+01	p
2,4-Dinitrotoluene	0.03290	0.33		
2,6-Dinitrotoluene	0.20900	0.33		
2-Chloronaphthalene	0.21500	0.33		
2-Chlorophenol	0.02330	0.33		
2-Methylnaphthalene	0.18900	0.33		
2-Nitroaniline	0.19500	0.33		
2-Nitrophenol	0.18000	0.33		
3,3'-Dichlorobenzidine	0.06400	1.6		
3-Nitroaniline	0.21200	0.33		
4,6-Dinitro-2-methylphenol	0.20700	1.6		
4-Bromophenyl phenyl ether	0.20000	0.33		
4-Chloro-3-methylphenol	0.19200	0.33		
4-Chloroaniline	0.06600	0.33		
4-Chlorophenyl phenyl ether	0.19800	0.33		
Cresol, p- (4-methylphenol)	0.00279	0.33		

TABLE 13 - ECOLOGICAL SCREENING VALUES FOR SOIL

Chemicals of Interest	Laboratory Method Detection Limit [1] (mg/Kg)	Laboratory Reporting Limit[1] (mg/Kg)	TCEQ Ecological Benchmarks for Soil (mg/Kg) [2]	Notation [3]
4-Nitroaniline	0.18000	1.6		
4-Nitrophenol	0.18000	1.6	7.0E+00	i
Acenaphthene	0.18900	0.33	2.0E+01	p
Acenaphthylene	0.19200	0.33		
Aniline	0.05100	0.33		
Anthracene	0.20700	0.33		
Benzo(a)anthracene	0.20730	0.33		
Benzo(a)pyrene	0.18511	0.33		
Benzo(b)fluoranthene	0.01934	0.33		
Benzo(g,h,i)perylene	0.17530	0.33		
Benzo(k)fluoranthene	0.02941	0.33		
Benzyl alcohol	0.12730	0.33		
Bis(2-Chloroethoxy)methane	0.18600	0.33		
Bis(2-Chloroethyl)ether	0.03298	0.33		
Bis(2-Chloroisopropyl)ether	0.00884	0.33		
Bis(2-Ethylhexyl)phthalate	0.20004	0.33		
Butyl benzyl phthalate	0.20070	0.33		
Chrysene	0.20173	0.33		
Dibenz(a,h)anthracene	0.18983	0.33		
Dibenzofuran	0.19669	0.33		
Diethyl phthalate	0.20413	0.33	1.0E+02	p
Dimethyl phthalate	0.19970	0.33	2.0E+02	i
Di-n-butyl phthalate	0.21297	0.33	2.0E+02	p
Di-n-octyl phthalate	0.21357	0.33		
Fluoranthene	0.21082	0.33		
Fluorene	0.20319	0.33	3.0E+01	i
Hexachlorobenzene	0.20812	0.33		
Hexachlorocyclopentadiene	0.02227	0.33		
Hexachloroethane	0.02991	0.33		
Indeno(1,2,3-cd)pyrene	0.18100	0.33		
Isophorone	0.19387	0.33		
Nitrobenzene	0.04740	0.33	4.0E+01	i
n-Nitrosodi-n-propylamine	0.02859	0.33		
Pentachlorophenol	0.02212	1.6	5.0E+00	p
Phenanthrene	0.20300	0.33		
Phenol	0.03736	0.33	3.0E+01	i
Pyrene	0.22085	0.33		

Notes:
1. Method Detection Limit and Reporting Limit provided by Test America Laboratory, Houston, Texas.
2. TCEQ Ecological Benchmarks for Soil from Table 3-4 of the "Update to Guidance for Conducting Ecological Risk Assessments at Remediation Sites in Texas RG-263 (Revised)". January 2006. Per TCEQ, these values represent a No Observed Adverse Effect Level (NOAEL) concentration.
3. "p" indicates that the receptor of concern is a plant; "i" indicates that the receptor of concern is an invertebrate.

TABLE 14 - SOIL GAS AND VAPOR SAMPLE ANALYTE LIST

Chemicals of Interest	Laboratory Method Detection Limit[1] (ug/m3)	Laboratory Reporting Limit[1] (ug/m3)
Acetone	9.5	23.75
Benzene	4.79	9.58
Benzyl chloride	10.35	51.77
Bromodichloromethane	6.70	13.40
Bromoform	5.17	20.67
Bromomethane	7.77	15.53
2-Butanone (MEK)	8.85	29.49
Carbon disulfide	12.46	31.14
Carbon tetrachloride	6.29	12.58
Chlorobenzene	2.30	9.21
Dibromochloromethane	8.52	17.04
Chloroethane	3.96	10.55
Chloroform	4.88	9.77
Chloromethane	4.13	8.26
1,2-Dibromoethane (EDB)	7.68	15.37
1,2-Dichlorobenzene	5.41	12.02
1,3-Dichlorobenzene	4.81	24.05
1,4-Dichlorobenzene	6.01	24.05
Dichlorodifluoromethane	4.95	14.84
1,1-Dichloroethane	4.05	8.09
1,2-Dichloroethane	6.07	12.14
cis-1,2-Dichloroethene	3.17	7.93
trans-1,2-Dichloroethene	3.96	7.93
1,1-Dichloroethene	3.96	7.93
1,2-Dichloropropane	6.93	13.86
cis-1,3-Dichloropropene	4.54	9.08
trans-1,3-Dichloropropene	4.54	9.08
1,2-Dichloro-1,1,2,2-tetrafluoroethane	6.99	13.98
Ethylbenzene	4.34	8.68
4-Ethyltoluene	4.92	9.83
Hexachlorobutadiene	16.00	42.66
2-Hexanone	8.19	40.97
Methylene chloride	3.47	6.95
4-Methyl-2-pentanone (MIBK)	8.19	40.97
Styrene	4.26	8.52
1,1,2,2-Tetrachloroethane	6.87	13.73
Tetrachloroethene	6.78	13.56
Toluene	3.77	7.54
1,2,4-Trichlorobenzene	18.55	37.11
1,1,1-Trichloroethane	5.46	10.91
1,1,2-Trichloroethane	5.46	10.91
Trichloroethene	5.37	10.75
Trichlorofluoromethane	5.62	11.24
1,1,2-Trichloro-1,2,2-trifluoroethane	7.66	15.33
1,2,4-Trimethylbenzene	6.39	14.75
1,3,5-Trimethylbenzene	9.83	19.66
Vinyl acetate	35.21	70.42
Vinyl chloride	5.11	10.22
m,p-Xylene	8.68	17.37
o-Xylene	4.34	8.68
Xylenes, total	4.34	8.68
Naphthalene	15.73	31.45

Notes:

1. Method Detection Limit and Reporting Limit provided by Test America Laboratory, Los Angeles, California.
2. Limits provided are for the US EPA TO15 method.

TABLE 15 - DITCH SURFACE WATER ANALYTE LIST AND SCREENING VALUES

Chemicals of Interest	Laboratory Method Detection Limit[1] (mg/L)	Laboratory Reporting Limit[1] (mg/L)	Screening Value[2] (mg/L)
METALS[5]			
Aluminum	0.00599	0.5	6.95
Arsenic	0.00328	0.01	0.45
Barium	0.00160	0.02	35.80
Chromium[4]	0.00155	0.01	7.26
Cobalt	0.00063	0.01	--[3]
Copper	0.00145	0.01	101.30
Lead[4]	0.00290	0.01	8.21
Manganese	0.00084	0.01	586.00
Mercury[4]	0.00002	0.002	3.27
Nickel	0.00165	0.01	266.29
Selenium	0.00417	0.04	1.33
Thallium	0.00784	0.03	0.05
Vanadium	0.00169	0.01	1.30
Zinc[4]	0.00217	0.03	105.30
VOCs			
1,1,1,2-Tetrachloroethane	0.00009	0.001	--[3]
1,1,1-Trichloroethane	0.00012	0.001	3744.00
1,1,2,2-Tetrachloroethane	0.00016	0.001	--[3]
1,1,2-Trichloroethane	0.00018	0.001	--[3]
1,1-Dichloroethane	0.00016	0.001	--[3]
1,1-Dichloroethene	0.00013	0.001	199.70
1,1-Dichloropropene	0.00013	0.001	--[3]
1,2,3-Trichloropropane	0.00011	0.001	--[3]
1,2,4-Trichlorobenzene	0.00020	0.001	--[3]
1,2,4-Trimethylbenzene	0.00010	0.001	--[3]
1,2-Dibromo-3-chloropropane	0.00039	0.002	--[3]
1,2-Dibromoethane	0.00018	0.002	--[3]
1,2-Dichlorobenzene	0.00010	0.001	--[3]
1,2-Dichloroethane[4]	0.00013	0.001	124.90
1,2-Dichloropropane	0.00016	0.001	--[3]
1,3,5-Trimethylbenzene	0.00008	0.001	--[3]
1,3-Dichlorobenzene	0.00013	0.001	--[3]
1,3-Dichloropropane	0.00012	0.001	--[3]
1,4-Dichlorobenzene	0.00005	0.001	--[3]
2,2-Dichloropropane	0.00009	0.001	--[3]
2-Butanone	0.00076	0.002	11790.00
2-Chlorotoluene	0.00017	0.001	--[3]
2-Hexanone	0.00031	0.002	--[3]
4-Chlorotoluene	0.00180	0.001	--[3]
4-Methyl-2-pentanone	0.00031	0.002	166.40
Acetone	0.00200	0.002	66.60
Benzene	0.00013	0.001	95.00
Bromobenzene	0.00014	0.001	--[3]
Bromodichloromethane	0.00014	0.001	--[3]
Bromoform	0.00012	0.001	--[3]
Bromomethane	0.00022	0.002	--[3]
Carbon disulfide	0.00007	0.002	--[3]
Carbon tetrachloride	0.00013	0.001	106.50
Chlorobenzene	0.00011	0.001	--[3]
Chloroethane	0.00019	0.002	--[3]
Chloroform	0.00012	0.001	100.00

TABLE 15 - DITCH SURFACE WATER ANALYTE LIST AND SCREENING VALUES

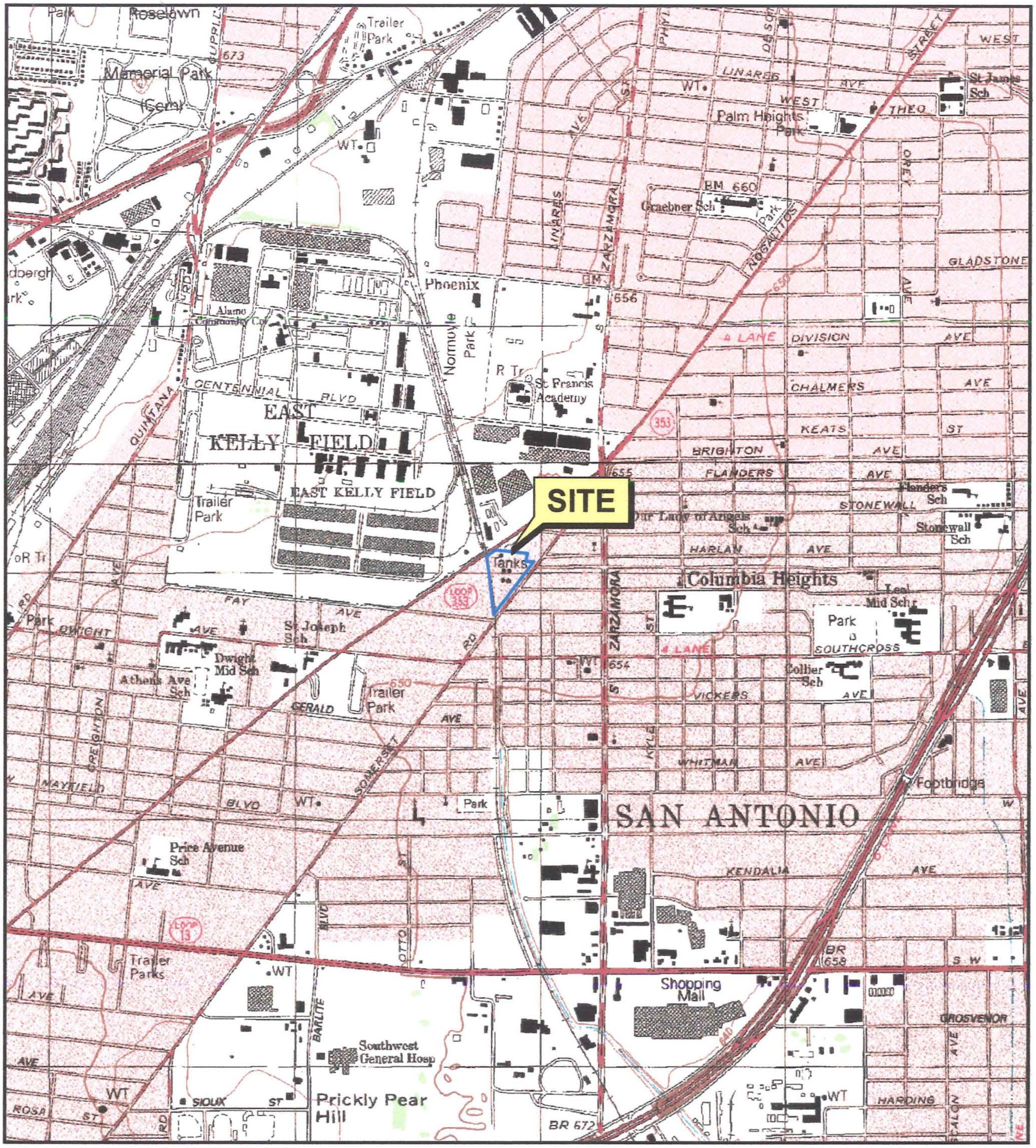
Chemicals of Interest	Laboratory Method Detection Limit[1] (mg/L)	Laboratory Reporting Limit[1] (mg/L)	Screening Value[2] (mg/L)
Chloromethane	0.00015	0.002	--[3]
cis-1,2-Dichloroethene	0.00016	0.001	--[3]
cis-1,3-Dichloropropene	0.00011	0.001	--[3]
Dibromochloromethane (chlorodibromomethane)	0.00045	0.001	--[3]
Dibromomethane	0.00052	0.001	--[3]
Dichlorodifluoromethane	0.00014	0.001	--[3]
Ethylbenzene	0.00013	0.001	--[3]
Hexachlorobutadiene	0.00017	0.001	--[3]
Isopropylbenzene (Cumene)	0.00006	0.001	--[3]
Methyl iodide (iodomethane)	0.00200	0.002	--[3]
Methylene chloride	0.00042	0.002	38.90
Naphthalene	0.00047	0.001	--[3]
n-Butylbenzene	0.00009	0.001	--[3]
n-Propylbenzene	0.00025	0.001	--[3]
p-Isopropyltoluene	0.00100	0.001	--[3]
sec-Butylbenzene	0.00014	0.001	--[3]
Styrene	0.00010	0.001	--[3]
tert-Butyl methyl ether (MTBE)	0.00015	0.001	--[3]
tert-Butylbenzene	0.00016	0.001	--[3]
Tetrachloroethene	0.00008	0.001	--[3]
Toluene	0.00014	0.001	93.70
trans-1,2-Dichloroethene	0.00012	0.001	--[3]
trans-1,3-Dichloropropene	0.00011	0.001	--[3]
Trichloroethene	0.00013	0.001	2.52
Trichlorofluoromethane	0.00008	0.001	--[3]
Vinyl chloride	0.00013	0.002	1.13
Xylenes (total)	0.00032	0.001	7.56
SVOCs			
2,4,5-Trichlorophenol	0.00025	0.015	--[3]
2,4,6-Trichlorophenol	0.00018	0.015	--[3]
2,4-Dichlorophenol	0.00015	0.015	--[3]
2,4-Dimethylphenol	0.00031	0.015	--[3]
2,4-Dinitrophenol	0.00039	0.015	--[3]
2,4-Dinitrotoluene	0.00100	0.015	--[3]
2,6-Dinitrotoluene	0.00008	0.015	--[3]
2-Chloronaphthalene	0.00008	0.015	--[3]
2-Chlorophenol	0.00013	0.015	--[3]
2-Methylnaphthalene	0.00007	0.015	--[3]
2-Nitroaniline	0.00019	0.015	--[3]
2-Nitrophenol	0.00022	0.015	--[3]
3,3'-Dichlorobenzidine	0.00018	0.015	--[3]
3-Nitroaniline	0.00018	0.015	--[3]
4,6-Dinitro-2-methylphenol	0.00083	0.015	--[3]
4-Bromophenyl phenyl ether	0.00010	0.015	--[3]
4-Chloro-3-methylphenol	0.00017	0.015	--[3]
4-Chloroaniline	0.00021	0.015	--[3]
4-Chlorophenyl phenyl ether	0.00010	0.015	--[3]
Cresol, p- (4-methylphenol)	0.00011	0.015	--[3]
4-Nitroaniline	0.00025	0.015	--[3]
4-Nitrophenol	0.00056	0.015	--[3]
Acenaphthene	0.00007	0.015	--[3]
Acenaphthylene	0.00008	0.015	--[3]

TABLE 15 - DITCH SURFACE WATER ANALYTE LIST AND SCREENING VALUES

Chemicals of Interest	Laboratory Method Detection Limit[1] (mg/L)	Laboratory Reporting Limit[1] (mg/L)	Screening Value[2] (mg/L)
Aniline	0.00008	0.015	--[3]
Anthracene	0.00007	0.015	--[3]
Benzo(a)anthracene	0.00012	0.015	--[3]
Benzo(a)pyrene	0.00008	0.015	3.60
Benzo(b)fluoranthene	0.00016	0.015	--[3]
Benzo(g,h,i)perylene	0.00013	0.015	--[3]
Benzo(k)fluoranthene	0.00012	0.015	--[3]
Benzyl alcohol	0.00017	0.015	--[3]
Bis(2-Chloroethoxy)methane	0.00013	0.015	--[3]
Bis(2-Chloroethyl)ether	0.00015	0.015	--[3]
Bis(2-Chloroisopropyl)ether	0.00040	0.015	--[3]
Bis(2-Ethylhexyl)phthalate[4]	0.00037	0.015	7.99
Butyl benzyl phthalate	0.00012	0.015	--[3]
Chrysene	0.00013	0.015	--[3]
Dibenz(a,h)anthracene	0.00050	0.015	--[3]
Dibenzofuran	0.00008	0.015	--[3]
Diethyl phthalate	0.00150	0.015	16508.00
Dimethyl phthalate	0.00007	0.015	--[3]
Di-n-butyl phthalate[4]	0.00011	0.015	0.80
Di-n-octyl phthalate	0.00016	0.015	--[3]
Fluoranthene	0.00008	0.015	--[3]
Fluorene	0.00007	0.015	--[3]
Hexachlorobenzene	0.00011	0.015	--[3]
Hexachlorocyclopentadiene	0.00013	0.015	--[3]
Hexachloroethane	0.00010	0.015	--[3]
Indeno(1,2,3-cd)pyrene	0.00010	0.015	--[3]
Isophorone	0.00011	0.015	--[3]
Nitrobenzene	0.00011	0.015	--[3]
n-Nitrosodi-n-propylamine	0.00010	0.015	--[3]
Pentachlorophenol	0.00061	0.015	1.60
Phenanthrene	0.00009	0.015	--[3]
Phenol	0.00004	0.015	--[3]
Pyrene	0.00009	0.015	--[3]

Notes:
1. Method Detection Limit and Reporting Limit provided by Test America Laboratory, Houston, Texas.
2. Screening Values for white-footed mouse via surface water exposure from Sample, et al, 1996 Appendix D, Table 12. (Sample, B.E., D.M. Opresko, and G.W. Suter, II. Toxicological Benchmarks for Wildlife: 1996 Revision. Health Sciences Research Division. Oak Ridge National Laboratory. ES/ER/TM-86/R3. June.)
3. -- = No screening value published.
4. The mammalian value was used as the screening value unless the avian value was lower; if avian value was lower, the American robin benchmark was used as the screening value.
5. Concentrations will be measured as total metals.

FIGURES



QUADRANGLE LOCATIONS

N

Scale in Feet

0 1000 2000

Source:
http://www.tnris.state.tx.us Terrell Wells and San Antonio West, TX 7.5 min. U.S.G.S. quadrangles, 1992 and 1993.

R&H OIL/TROPICANA ENERGY SITE

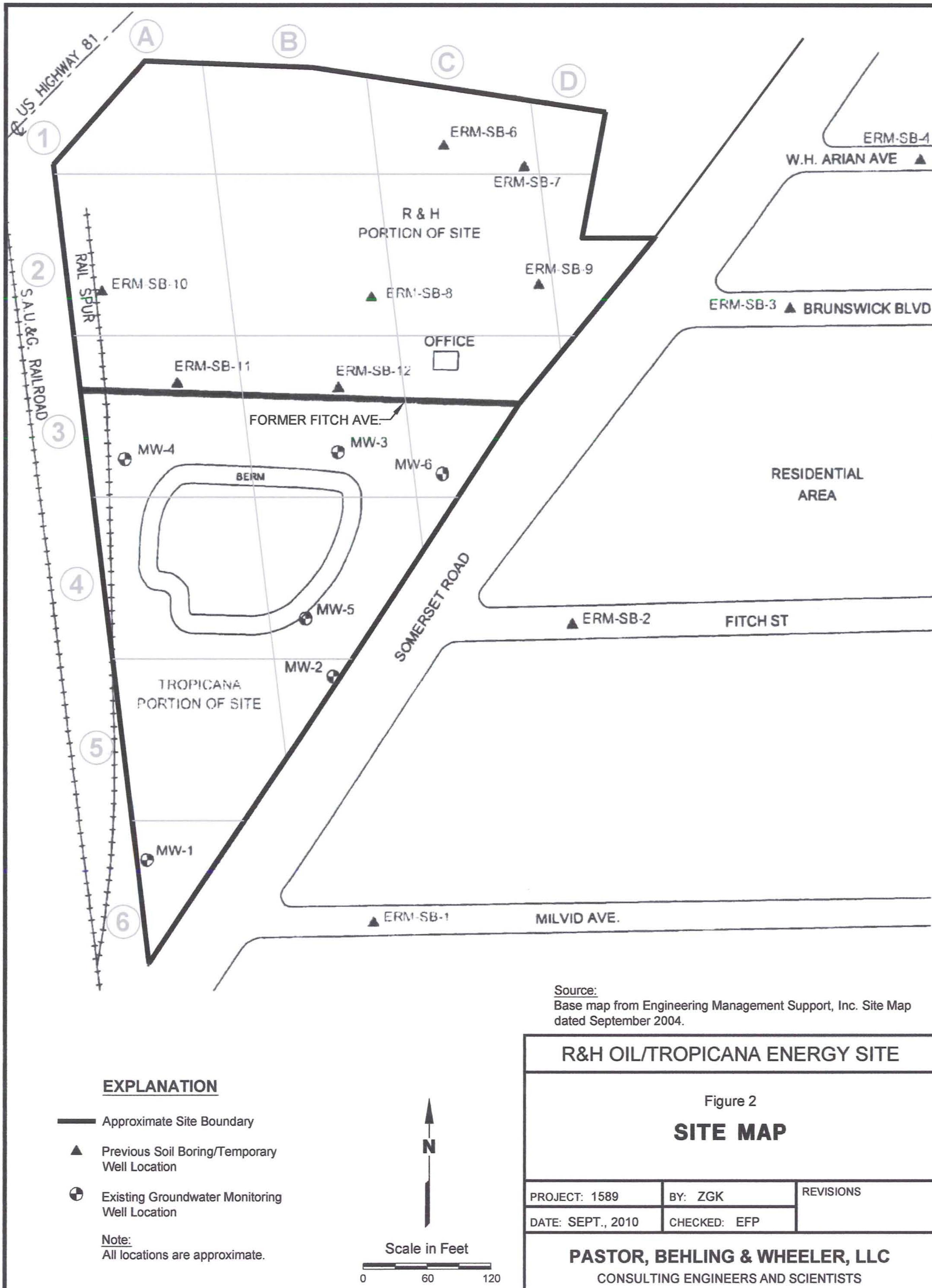
Figure 1

SITE LOCATION MAP

PROJECT: 1589	BY: ZGK	REVISIONS
DATE: SEPT., 2010	CHECKED: EFP	

PASTOR, BEHLING & WHEELER, LLC

CONSULTING ENGINEERS AND SCIENTISTS



Source:
Base map from Engineering Management Support, Inc. Site Map dated September 2004.

R&H OIL/TROPICANA ENERGY SITE		
Figure 2 **SITE MAP**		
PROJECT: 1589	BY: ZGK	REVISIONS
DATE: SEPT., 2010	CHECKED: EFP	
PASTOR, BEHLING & WHEELER, LLC CONSULTING ENGINEERS AND SCIENTISTS		

NOTES:

1. ALL COORDINATES AND BEARINGS ARE RELATIVE TO THE TEXAS STATE PLANE COORDINATE SYSTEM, SOUTH CENTRAL ZONE (NAD 83).
2. ALL DISTANCES ARE HORIZONTAL SURFACE LEVEL LENGTHS (SF= 0.99983626426).
3. ELEVATIONS ARE RELATIVE TO THE NAVD 88 (AS DETERMINED BY GEOID99) AND ARE BASED ON THE NGS CORS STATION EZSA.

EXPLANATION

- 657.5 Ground Surface Elevation Contour (Ft MSL)
- Power Pole
- OH Overhead Wire
- Guy Anchor
- Top Bank Berm
- Toe of Slope
- Chain-link Fence
- S Utility Sign
- Projected Portion of Site with Direct Surface Water Runoff to Drainage Ditch West of Site

Source:
Topographic map develop by Doyle & Wachtstetter, Inc. based on survey performed September 20, 2007.

R&H OIL/TROPICANA ENERGY SITE

Figure 3

SITE TOPOGRAPHIC MAP

PROJECT: 1589	BY: ZGK	REVISIONS
DATE: SEPT., 2010	CHECKED: EFP	

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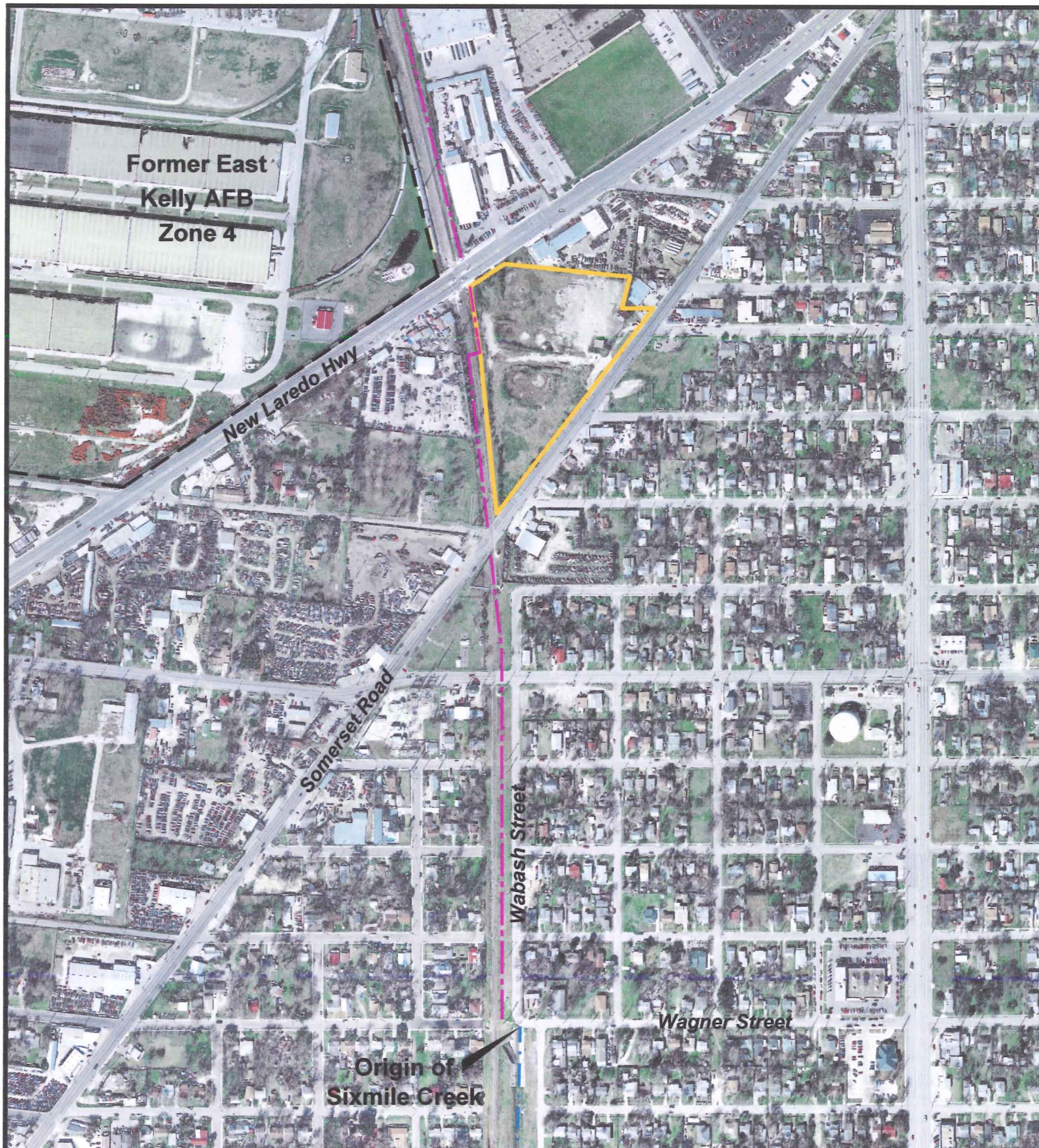

EXPLANATION

Approx. Site Boundary

Drainage Ditch

Sixmile Creek

Note:
Location for origin of Sixmile Creek based on USGS San Antonio West quadragle.

Approx. Scale in Feet

0 250 500

Source:
http://imageserver.sanantonio.gov aerial photograph.

R&H OIL/TROPICANA ENERGY SITE

Figure 4

DRAINAGE DITCH LOCATION

PROJECT: 1589	BY: ZGK	REVISIONS
DATE: SEPT., 2010	CHECKED: EFP	

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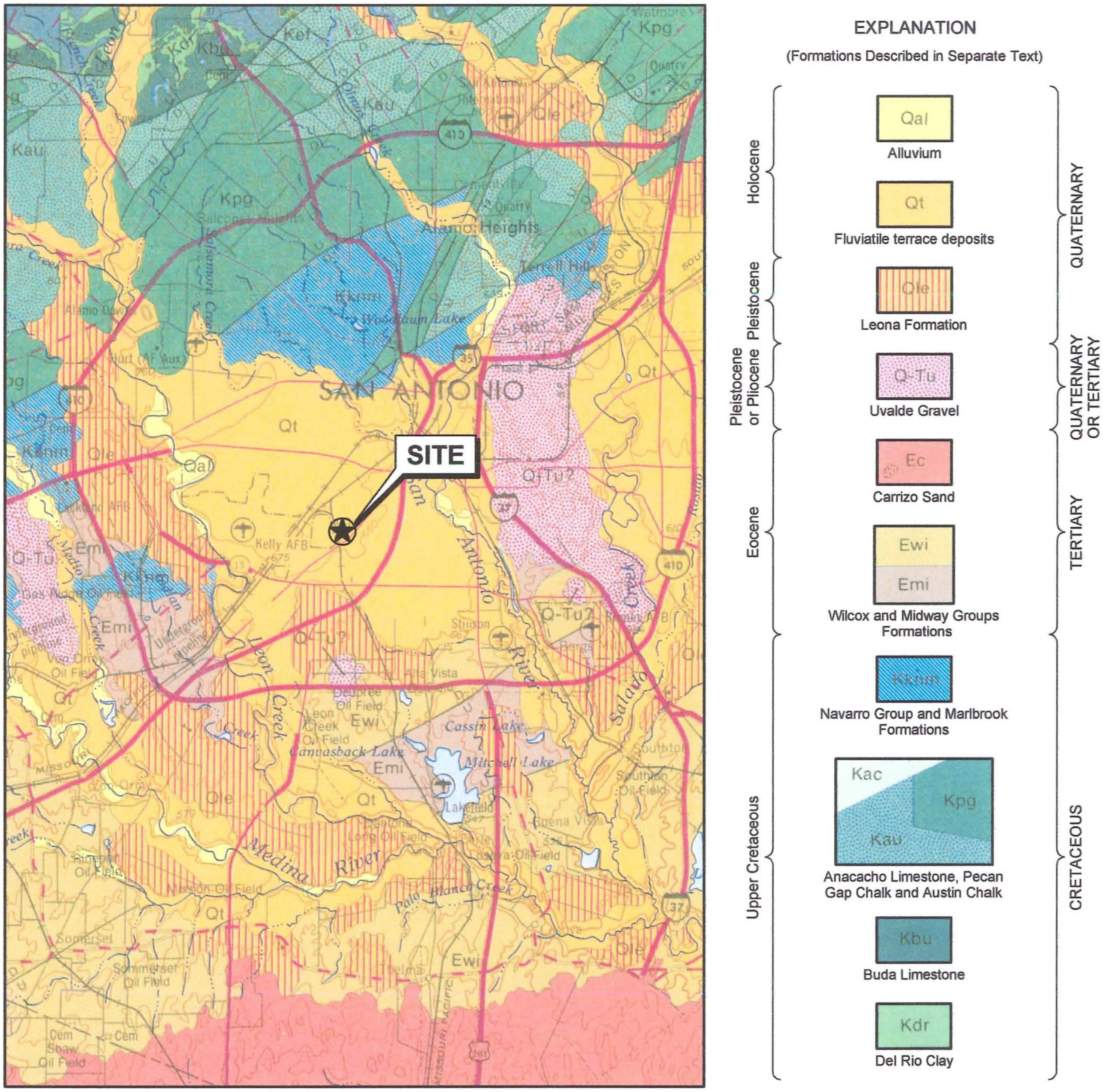

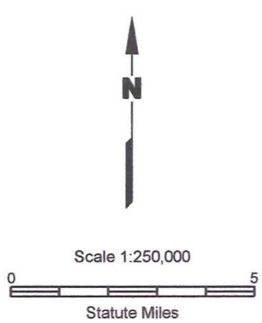

Source:
Bureau of Economic Geology. Geologic Atlas of Texas, San Antonio Sheet (Revised 1982).

R&H OIL/TROPICANA ENERGY SITE

Figure 5

REGIONAL GEOLOGIC MAP

PROJECT: 1589	BY: ZGK	REVISIONS
DATE: SEPT., 2010	CHECKED: EFP	

PASTOR, BEHLING & WHEELER, LLC
CONSULTING ENGINEERS AND SCIENTISTS

EXPLANATION

Site Boundary Fence

Soil Boring/Temporary Well

Groundwater Monitoring Well

Composite Soil Sample

Composite Soil Area

Grab Soil Sample

Note: All locations are approximate.

N

Approx. Scale in Feet

0 60 120

Source:
http://imageserver.sanantonio.gov aerial photograph, 8/19/03. Sample locations from Removal Site Evaluation Reports (E&E, August 1998) and ERM Site Investigation Report (September 2004).

R&H OIL/TROPICANA ENERGY SITE

Figure 6

PREVIOUS INVESTIGATION LOCATIONS

PROJECT: 1589	BY: ZGK	REVISIONS
DATE: SEPT., 2010	CHECKED: EFP	

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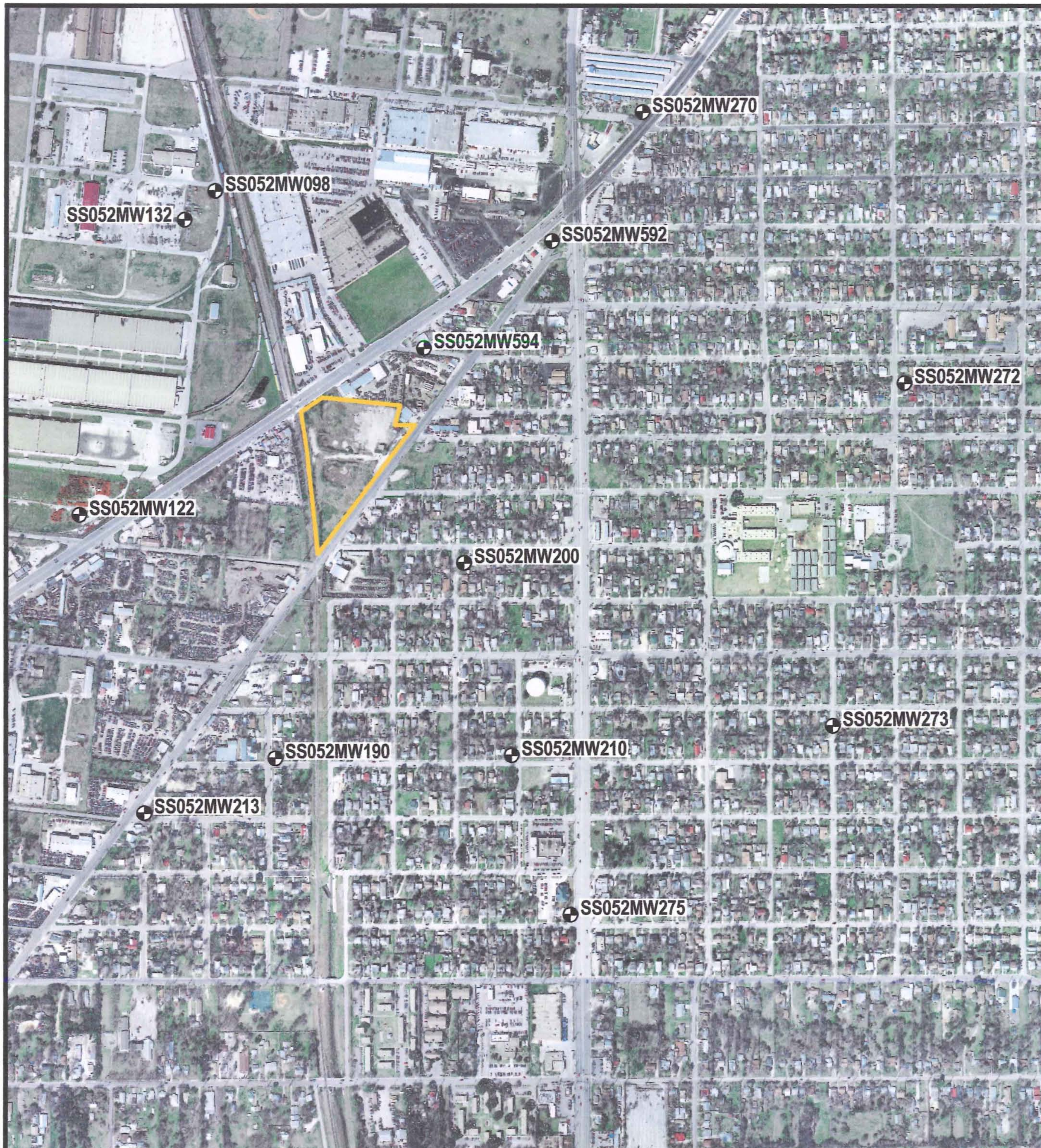
CONSULTING ENGINEERS AND SCIENTISTS



EXPLANATION

Approx. Site Boundary

Groundwater Monitoring Well

Note: All locations are approximate.

N

Approx. Scale in Feet

0 400 800

Source:
http://imageserver.sanantonio.gov aerial photograph, 8/19/03. Sample locations from Removal Site Evaluation Reports (E&E, August 1998) and ERM Site Investigation Report (September 2004).

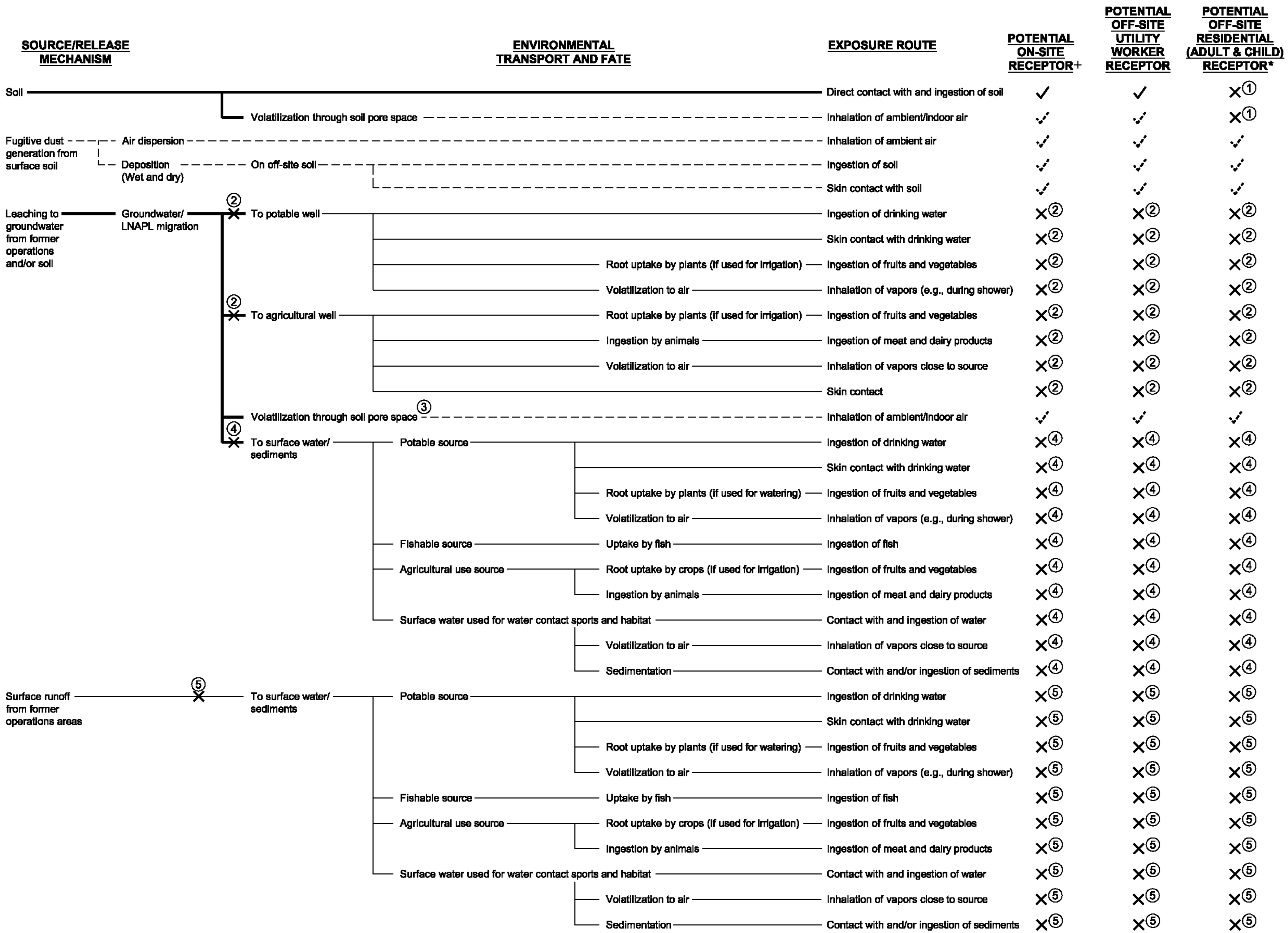
R&H OIL/TROPICANA ENERGY SITE

Figure 7

SELECTED FORMER EAST KELLY AIR FORCE BASE GROUNDWATER MONITORING WELLS

PROJECT: 1589	BY: ZGK	REVISIONS
DATE: SEPT., 2010	CHECKED: EFP	

PASTOR, BEHLING & WHEELER, LLC
CONSULTING ENGINEERS AND SCIENTISTS



LEGEND:

- Pathway is Incomplete
- Pathway is Potentially Complete
- Pathway is Complete, Potentially Significant

NOTES:

1. Pathway applies to on-site receptors only.
2. TNRCC Site Screening Report (TNRCC, 2000) indicates that no water wells from the shallow aquifer are being used for drinking or irrigation.
3. In the Public Health Assessment for the R&H Oil Company & Tropicana Energy Company Site (ATSDR, 2003), ATSDR noted that this pathway was evaluated in a petitioned public health assessment for the nearby East Kelly Air Force Base site which concluded that soil gas migration from contaminated groundwater to indoor air of nearby residents posed no apparent public health hazard.
4. Groundwater discharge to surface water is not occurring at or near the Site.
5. The surface water pathway is incomplete because there is no overland flow segment or flood potential for the Site and the nearest perennial surface waters are located approximately 3 miles southwest of the Site.

\+ Receptor includes maintenance, and commercial/ industrial workers, and trespassers.

✓ Indicates potential receptor for complete migration pathway.

✓' Potentially complete pathway (i.e., pathway for which additional data are needed).

* Receptor includes a pregnant female.

× Incomplete pathway.

R&H OIL/TROPICANA ENERGY SITE

Figure 8

HUMAN HEALTH CONCEPTUAL SITE MODEL

PROJECT: 1589	BY: ZGK	REVISIONS
DATE: SEPT., 2010	CHECKED: KHT	

PASTOR, BEHLING & WHEELER, LLC
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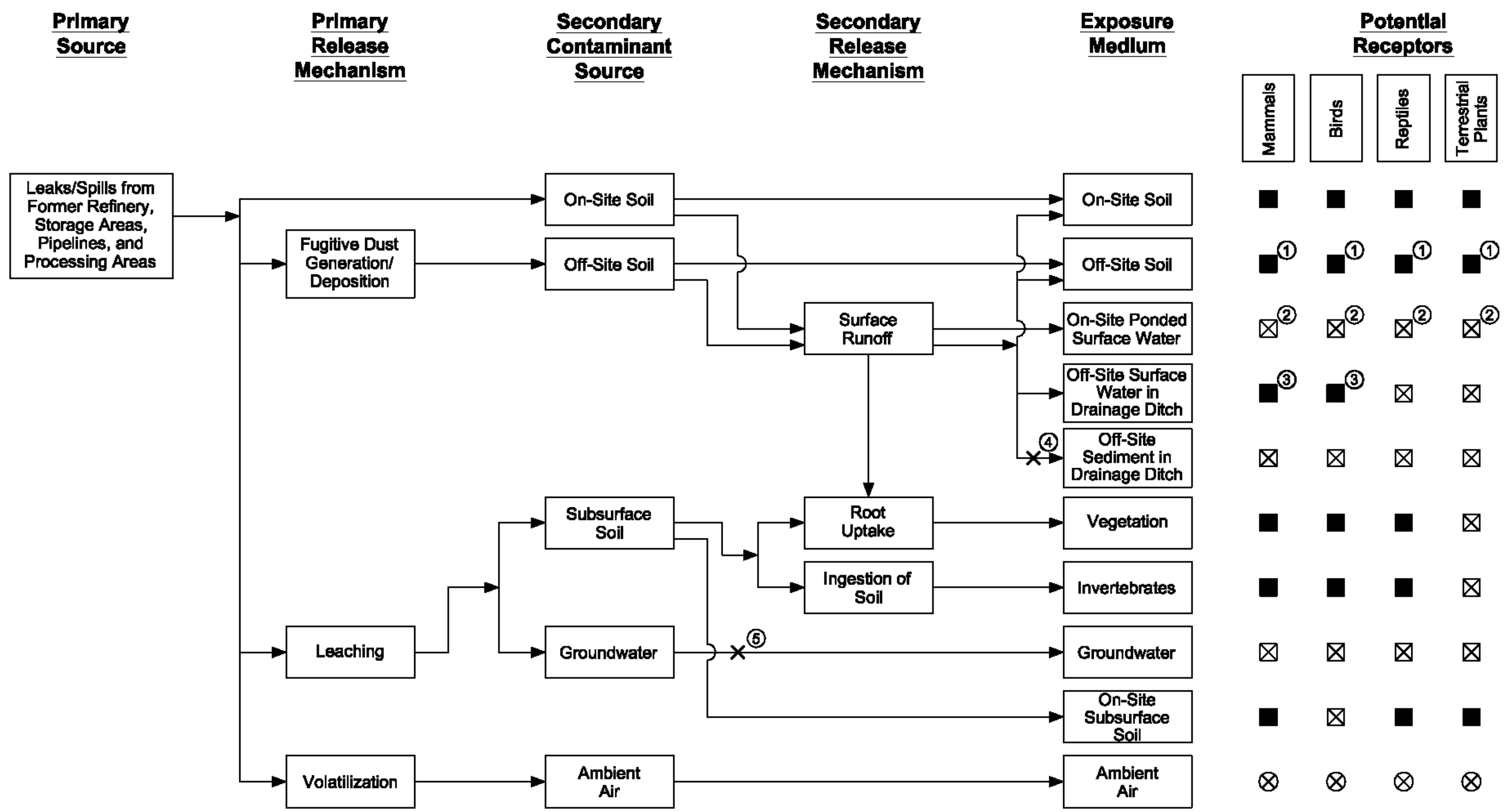

LEGEND

- ■ Pathway is complete
- ⊠ Pathway is incomplete
- ⊗ Pathway is potentially complete, not evaluated

NOTES:

1. If on-site soil indicates that off-site soil migration pathway may be complete and significant, potential risks to off-site soil will be assessed.
2. On-site ponded water pathways are considered incomplete since it is only present after heavy rainfall.
3. Surface water in the off-site drainage ditch that runs along a portion of the western side of the site will be evaluated if it is present.
4. Because of the ephemeral nature of the ditch, "true" sediments are not present and therefore, sediment exposure scenarios and related screening levels are not applicable.
5. The depth to groundwater precludes exposure to most, if not all, receptors.

R&H OIL/TROPICANA ENERGY SITE

Figure 9

ECOLOGICAL CONCEPTUAL SITE MODEL

PROJECT: 1589	BY: ZGK	REVISIONS
DATE: SEPT., 2010	CHECKED: KHT	

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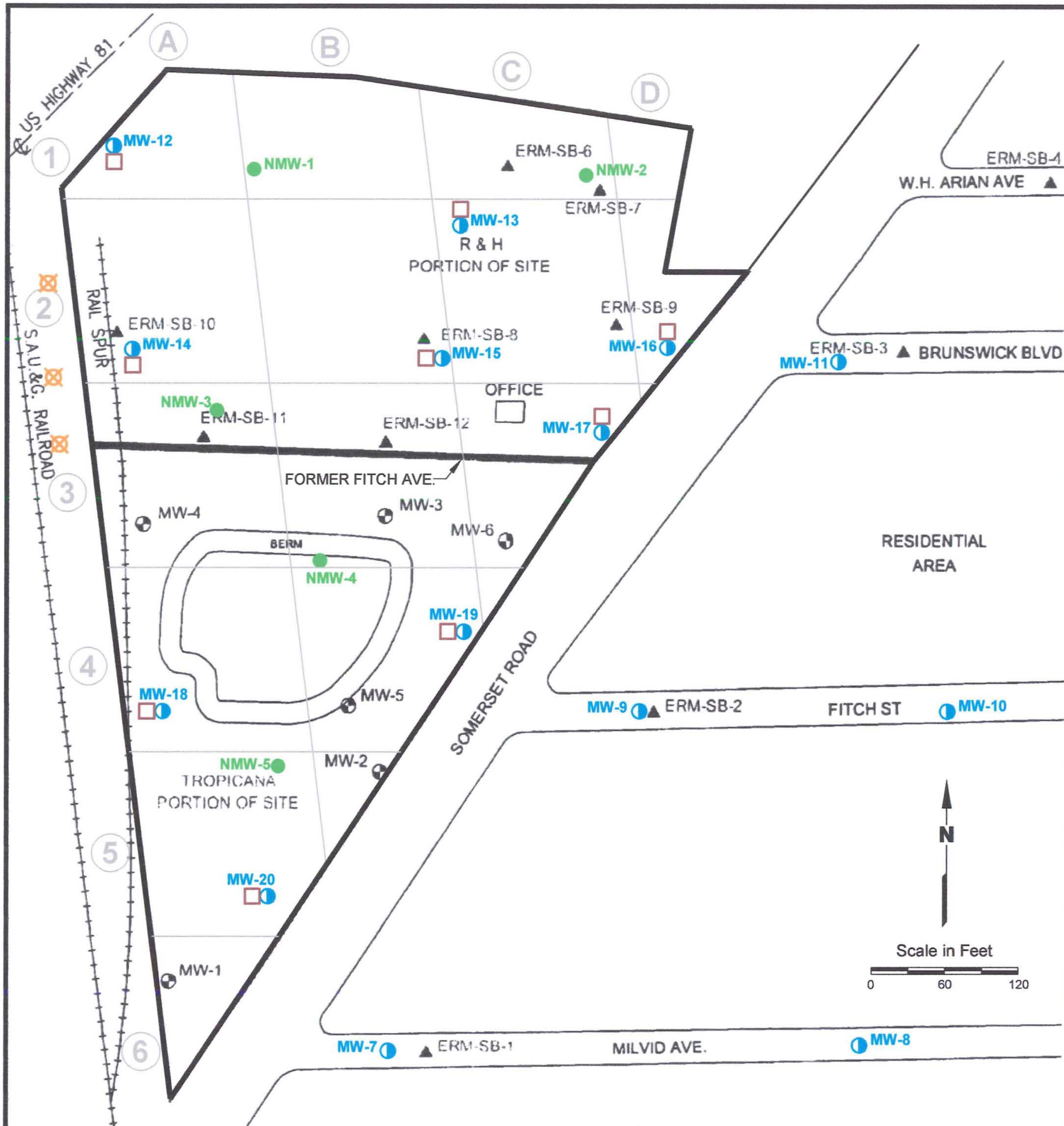


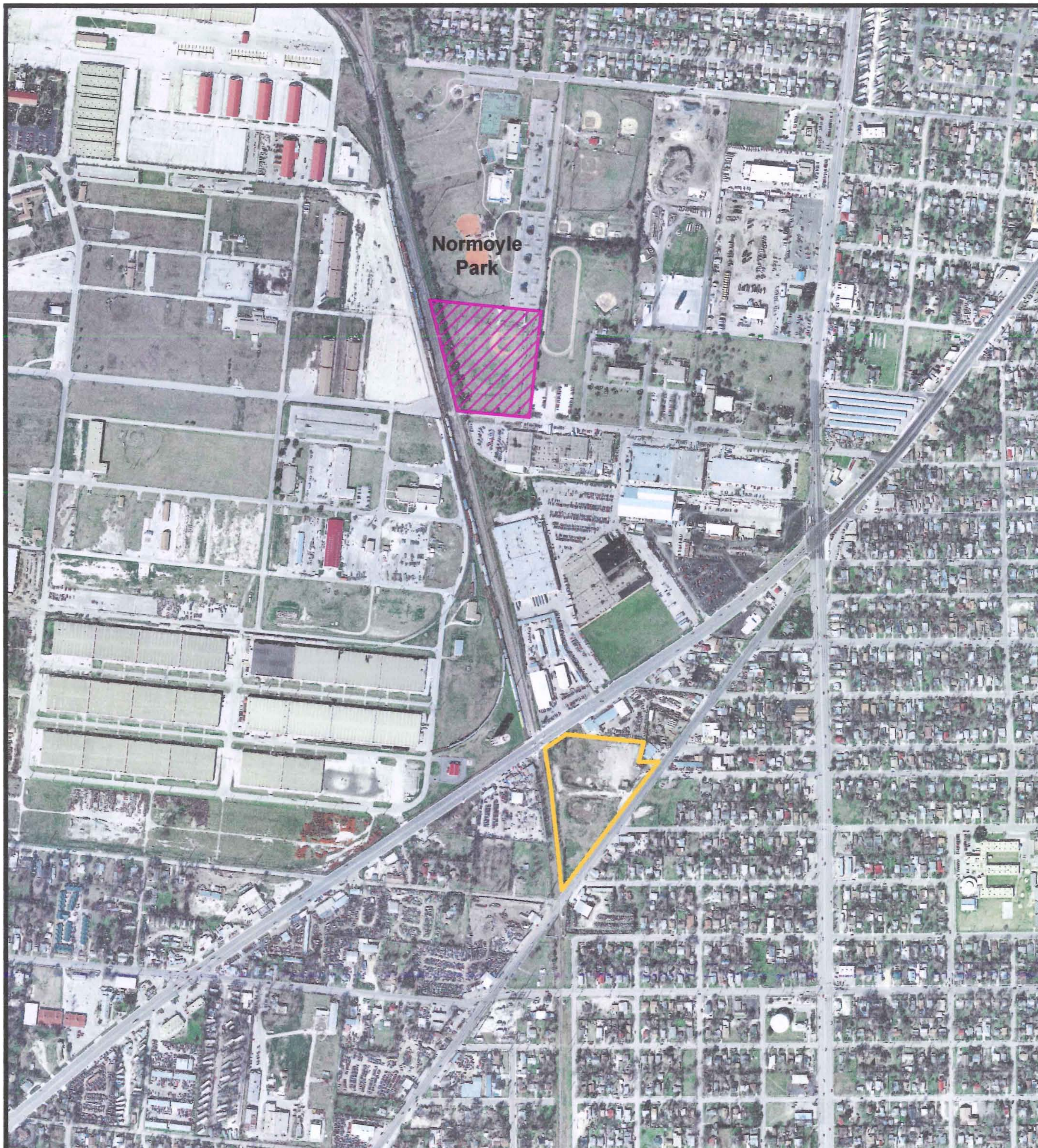
EXPLANATION

- Approximate Site Boundary
- Previous Soil Boring/Temporary Well Location
- Existing Groundwater Monitoring Well Location
- RI/FS Soil Boring/Groundwater Monitoring Well Location
- RI/FS Soil Boring/NAPL Monitoring Well Location
- RI/FS Soil Gas Sample Location
- Ditch Surface Water Sample Location (upstream sample locations to be determined at time of sampling).

Notes:
1. All locations are approximate.
2. RI/FS locations subject to modification based on field conditions.
2. Test pit locations will be determined based on soil boring and monitoring well data, and thus are not shown on this figure.

Source:
Base map from Engineering Management Support, Inc. Site Map dated September 2004.

R&H OIL/TROPICANA ENERGY SITE		
Figure 10 **PROPOSED RI/FS SAMPLE LOCATIONS**		
PROJECT: 1589	BY: ZGK	REVISIONS
DATE: SEPT., 2010	CHECKED: EFP	
PASTOR, BEHLING & WHEELER, LLC CONSULTING ENGINEERS AND SCIENTISTS		



EXPLANATION

Approx. Site Boundary

Proposed Background Soil Sampling Area

Source:
http://imageserver.sanantonio.gov aerial photograph, 8/19/03. Sample locations from Removal Site Evaluation Reports (E&E, August 1998) and ERM Site Investigation Report (September 2004).

R&H OIL/TROPICANA ENERGY SITE

Figure 11

PROPOSED RI/FS BACKGROUND SOIL AREA (IF NEEDED)

PROJECT: 1589	BY: ZGK	REVISIONS
DATE: SEPT., 2010	CHECKED: EFP	

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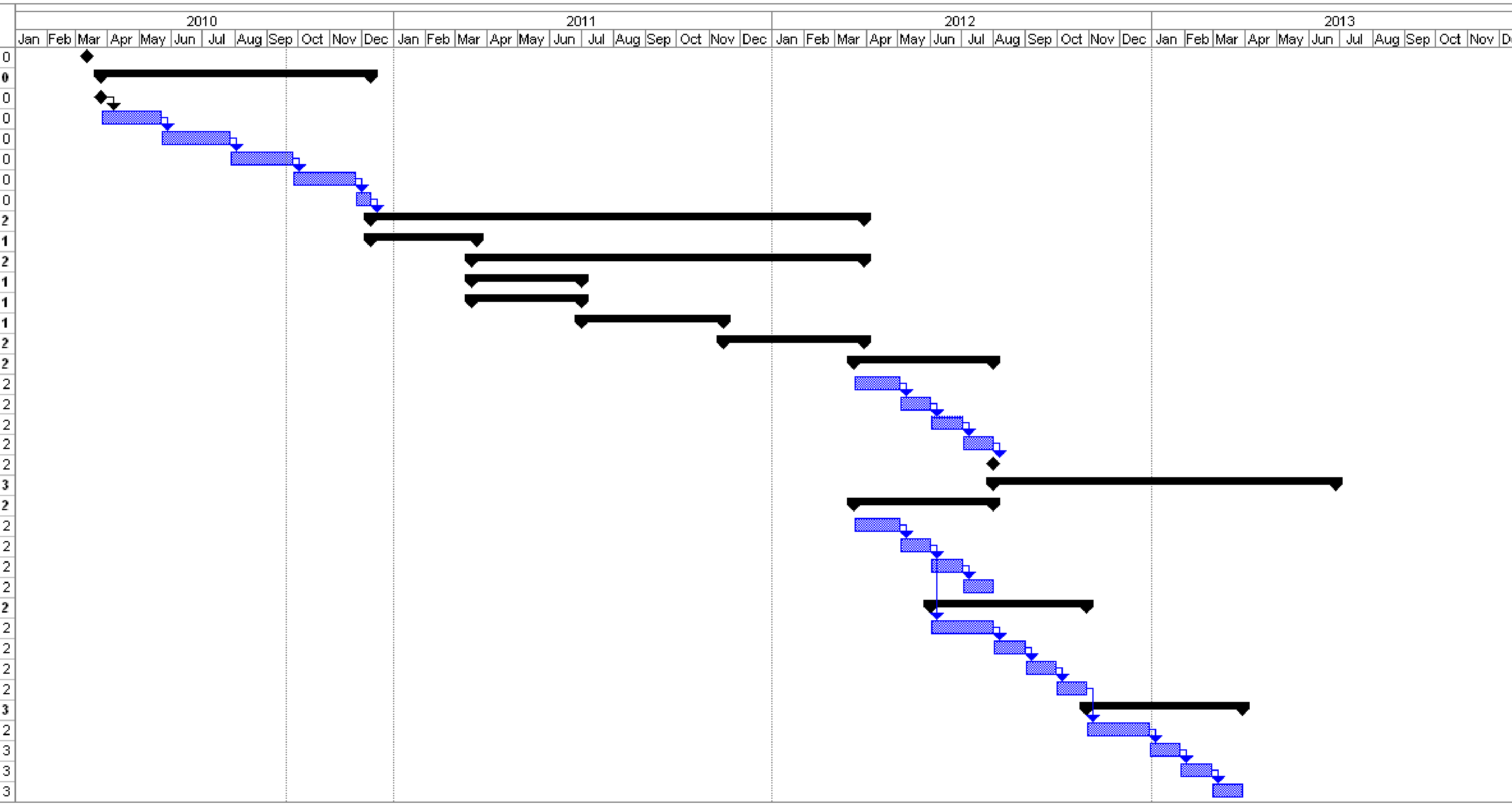
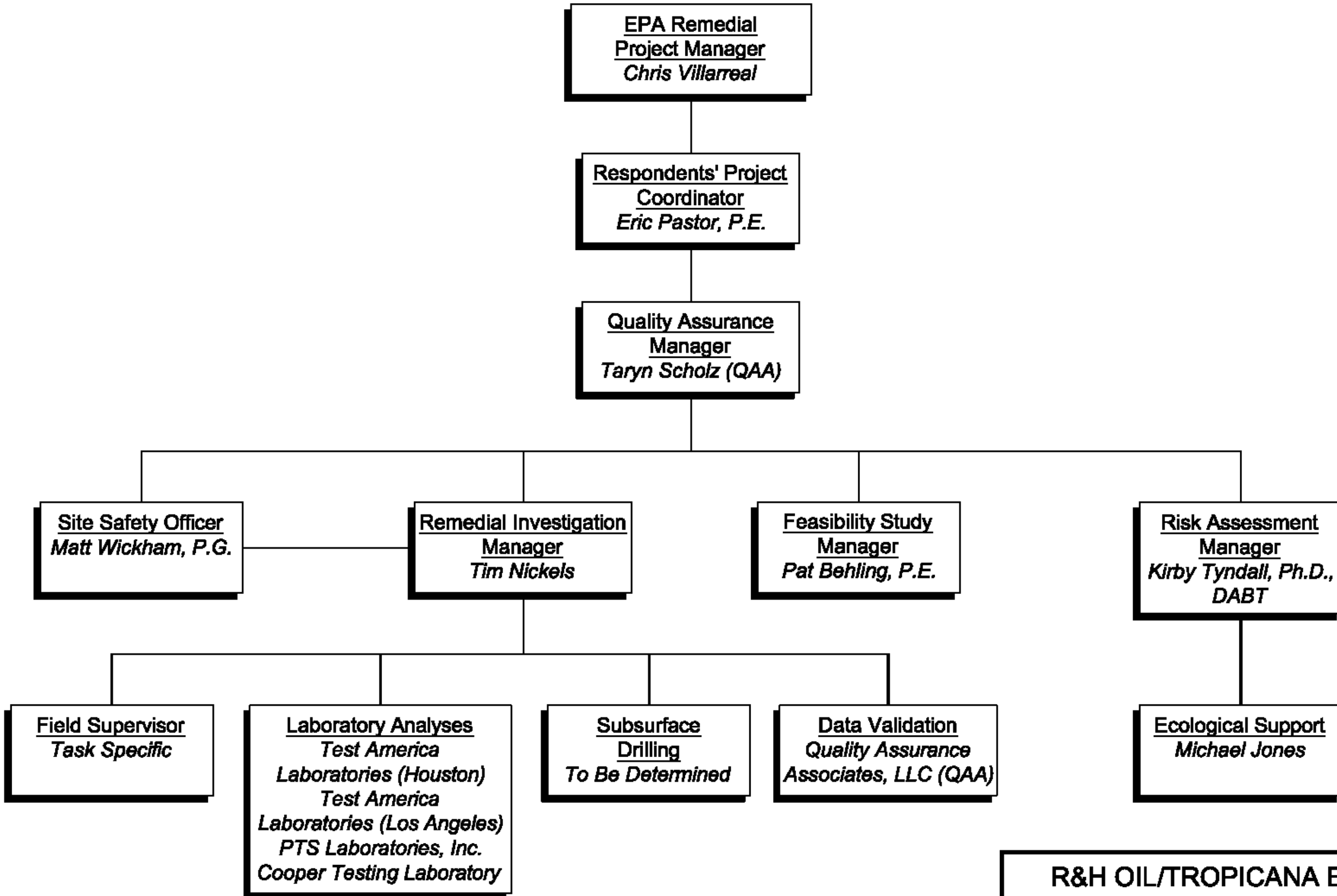
FIGURE 12
PROJECTED SCHEDULE

Task Name	Duration	Start	Finish
Effective Date of AOC	0 days	Fri 3/12/10	Fri 3/12/10
Scoping	**260 days**	**Wed 3/24/10**	**Thu 12/9/10**
Scoping Meeting	0 days	Wed 3/24/10	Wed 3/24/10
Prepare Draft RI/FS WP, SAP (FSP/QAAP), HSP - PBW	58 days	Thu 3/25/10	Fri 5/21/10
Review/Comment on Draft RI/FS WP, SAP (FSP/QAAP), HSP - EPA	67 days	Sat 5/22/10	Tue 7/27/10
Prepare Final RI/FS WP, SAP (FSP/QAAP), HSP - PBW	60 days	Wed 7/28/10	Sat 9/25/10
Review/Approve Final RI/FS WP, SAP (FSP/QAAP), HSP - EPA	60 days	Sun 9/26/10	Wed 11/24/10
Provide Field Notice and Insurance Certificates to EPA - PBW	15 days	Thu 11/25/10	Thu 12/9/10
Site Characterization	**475 days**	**Fri 12/10/10**	**Wed 3/28/12**
Off-site Groundwater Investigation (5 wells)	**102 days**	**Fri 12/10/10**	**Mon 3/21/11**
Site Soil and Groundwater Investigation	**378 days**	**Thu 3/17/11**	**Wed 3/28/12**
Phase 1 Investigation - 14 soil borings, 14 wells	**106 days**	**Thu 3/17/11**	**Thu 6/30/11**
Ditch Surface Water Sampling	**106 days**	**Thu 3/17/11**	**Thu 6/30/11**
Background Soil Investigation (if needed)	**137 days**	**Fri 7/1/11**	**Mon 11/14/11**
Phase 2 Investigation - (soil gas, subslab sampling)	**135 days**	**Tue 11/15/11**	**Wed 3/28/12**
Screening Level Ecological Risk Assessment	**135 days**	**Mon 3/19/12**	**Tue 7/31/12**
Prepare Draft SLERA	45 days	Mon 3/19/12	Wed 5/2/12
Review/Comment on SLERA	30 days	Thu 5/3/12	Fri 6/1/12
Prepare Final SLERA	30 days	Sat 6/2/12	Sun 7/1/12
Review/Approve Final SLERA	30 days	Mon 7/2/12	Tue 7/31/12
SLERA SMDP	0 days	Tue 7/31/12	Tue 7/31/12
Baseline Ecological Risk Assessment (if needed)	**330 days**	**Wed 8/1/12**	**Wed 6/26/13**
Baseline Human Health Risk Assessment	**135 days**	**Mon 3/19/12**	**Tue 7/31/12**
Prepare Draft BHHRA	45 days	Mon 3/19/12	Wed 5/2/12
Review/Comment on Draft BHHRA	30 days	Thu 5/3/12	Fri 6/1/12
Prepare Final BHHRA	30 days	Sat 6/2/12	Sun 7/1/12
Review/Approve Final BHHRA	30 days	Mon 7/2/12	Tue 7/31/12
Remedial Investigation Report	**150 days**	**Sat 6/2/12**	**Mon 10/29/12**
Prepare Draft RI Report	60 days	Sat 6/2/12	Tue 7/31/12
Review/Comment on Draft RI Report	30 days	Wed 8/1/12	Thu 8/30/12
Prepare Final RI Report	30 days	Fri 8/31/12	Sat 9/29/12
Review/Approve Final RI Report	30 days	Sun 9/30/12	Mon 10/29/12
Feasibility Study Report	**150 days**	**Tue 10/30/12**	**Thu 3/28/13**
Prepare Draft FS Report	60 days	Tue 10/30/12	Fri 12/28/12
Review/Comment on Draft FS Report	30 days	Sat 12/29/12	Sun 1/27/13
Prepare Final FS Report	30 days	Mon 1/28/13	Tue 2/26/13
Review/Approve Final FS Report	30 days	Wed 2/27/13	Thu 3/28/13



Note: This schedule is subject to revision based on changes in assumed EPA review time periods, weather conditions, modifications or additions to the scope of work described herein based on the data obtained, and/or delays in obtaining access to any properties to be sampled.



R&H OIL/TROPICANA ENERGY SITE

Figure 13

PROJECT ORGANIZATION

PROJECT: 1589	BY: ZGK	REVISIONS
DATE: SEPT., 2010	CHECKED: EFP	

PASTOR, BEHLING & WHEELER, LLC

CONSULTING ENGINEERS AND SCIENTISTS

APPENDICES

APPENDIX A
SCOPING MEETING DISCUSSIONS AND NOTES

PBW

Consulting Engineers
and Scientists

PASTOR, BEHLING & WHEELER, LLC
2201 Double Creek Drive, Suite 4004
Round Rock, TX 78664

Tel (512) 671-3434
Fax (512) 671-3446

MEETING MINUTES

MEETING: ***R&H Oil/Tropicana Energy Site – EPA Scoping Phase Meeting***

LOCATION: EPA Region 6 - Dallas, TX

DATE: March 24, 2010

ATTENDEES: Mr. Chris Villarreal, EPA Project Manager
Mr. Ruben Moya, EPA Project Manager
Ms. Dipanjana Bhattacharya, EPA Human Health Risk Assessor
Ms. Stephen Harper, EPA Community Relations Coordinator
Mr. Gary Miller, EPA RCRA
Ms. Kathy Thomas, EPA Kelly AFB Project Manager
Mr. Eric Pastor, PBW, LLC
Dr. Kirby Tyndall, PBW, LLC
Mr. Tim Nickels, PBW, LLC
Mr. Michael Jones, PBW, LLC
Mr. Bob Sterrett, Itasca Denver, Inc.

DOCUMENT EXCHANGE:

Documents EPA Distributed at Meeting:

1. Copy of attendee sign in sheet (Attachment A to this memo).
2. Bexar County Appraisal District property search results and EPA Access Agreements (Attachment B to this memo).
3. Copy of Power Point slides (Attachment C to this memo).

Chris Villarreal began the meeting, facilitated introduction of attendees, and distributed materials he had prepared for the meeting.

Deliverables

Due within 60 days after the Scoping Phase Meeting

- RI/FS Site Health and Safety Plan
- Draft RI/FS Work Plan
- Draft RI/FS Sampling and Analysis Plan

Mr. Villarreal noted that the above deliverables were due May 24, 2010

PBW requested that agency recipients to be included on the distribution list for the deliverables be specifically identified (i.e., by name), as the list in the Settlement Agreement contains agencies/departments with no specific point of contact or addresses.

<u>Site Access</u>

Mr. Villarreal indicated PRP Site access needs to be obtained from the property owners with new access agreements. Mr. Villarreal suggested the access agreements be modeled on the previous EPA agreements (included in Attachment B). Mr. Pastor indicated the possibility that no response would be received from the property owners. EPA agreed that this could be a possibility and indicated that if the PRPs are unable to obtain access within 45 days of the scoping meeting as required by the Settlement Agreement, they should submit a letter to EPA documenting their attempts to obtain access.

Access Agreement contacts:

South Parcel (Partners Terminal)

- J. Kent Burt, PO Box 35, Exeter, CA 93221
  Physical address 1497 E. Marinette Ave., Exeter, CA 93221
- W.L. Martin, 339 W. California Blvd., Pasadena, CA 91105

North Parcel

- William Hickey, attorney and contact for Site communications on behalf of Margaret Sanchez, 208 E. Blanco, Boerne, TX 78006 Phone 830-249-5749
- Margaret Sanchez, PO Box 312372, New Braunfels, TX 78181

<u>Project Data</u>

The usefulness of historic data was discussed and it was agreed that previously collected soil data (1994 & 1996) were obsolete. Existing data (from investigations conducted since EPA removal of Site structures) will be used for scoping and to guide the RI/FS program, but will not be used for nature and extent determination or risk assessment. Only data collected during the RI/FS program will be used to determine nature and extent and to support the risk assessment.

It was agreed that the background soil study conducted for the Kelly AFB would provide useful information for the RI/FS and should be included in the project. Mr. Miller commented that the background study may be a bit dated. It was agreed that the Kelly background report could be incorporated by reference in to the RI/FS documents and did not need to be included as an attachment to the documents. Mr. Villarreal asked that PBW provide hard copies of the Kelly background soil reports independent of the RI/FS Work Plan. The need for Site background soil samples and the potential difficulty in finding an appropriate area to collect Site background samples was discussed. PBW agreed to propose an area for Site background soil sampling (if needed) in the Work Plan. Ms. Dipanjana Bhattacharya requested that any time values from the Kelly background study are used in the risk assessment or for comparison to background concentrations, that the values being used from the Kelly study be included.

Mr. Villarreal encouraged use of the passive soil gas sampling data for potentially adjusting proposed sampling locations. Mr. Villarreal indicated that the Beacon Environmental Services sampling protocol appears to be developing a good track record. It was agreed that this information could be incorporated by reference in to the RI/FS documents and did not need to be included as an attachment to the documents as it is already a part of the project record. PBW noted that the Beacon data had already been used to modify some of the proposed soil boring/monitoring well locations in the final version of the Scope of Work.

There was some discussion about possible collection of split samples from pertinent wells samples as part of the Kelly program. Mr. Pastor noted that the Air Force had previously denied a request for collecting these samples. Mr. Villarreal and Mr. Miller noted that there are new contacts on the Kelly project now and split sampling may be possible (Mr. Villarreal provided that contact information via e-mail after the meeting).

Access to the reports generated for the routine, off-site groundwater monitoring events conducted for Kelly AFB was discussed. Due to occasional difficulties in obtaining the reports from the central records section of the TCEQ, PBW requested that EPA provide the semi-annual groundwater reports directly if possible. EPA indicated that this may be best accomplished using the Environmental Science Connector (ESC) website to share project data. EPA indicated they would place sections of the reports (they are very large files) on the ESC site or provide the entire reports via CD. PBW requested that the most current data reports be provided for consideration in the Work Plan preparation (Mr. Villarreal provided a CD with the current data to PBW via Fed Ex after the meeting).

Mr. Villarreal described the ESC website and his vision for its use as an informal document repository. It was proposed that Mr. Pastor be given permissions that would allow for adding and removing items from the web site. Mr. Pastor indicated that many of the PRPs may be interested in Site access, to which Mr. Villarreal indicated the web site may not support a large number of users and another option may need to be considered. Mr. Pastor said that he would provide a list of the PRPs requesting access and Mr. Villarreal would evaluate whether the website could support that list thereafter. Mr. Villarreal emphasized that use of the website for informal sharing of documents would not replace any of the AOC requirements for submittal of hard copy draft and final deliverables.

Mr. Villarreal mentioned a vapor intrusion (VI) investigation at Kelly AFB as a potential source of reference material for evaluating VI at the Site. Mr. Miller indicated that the study ultimately found there were very low VI impacts observed, and that most homes evaluated were of pier-and-beam construction (generally the same construction type as homes in the vicinity of the R&H Site). Specifically, it was noted that only one of eight homes where indoor air had been sampled in the study produced samples with detectable contaminant concentrations, and these concentrations were determined to be below potential risk levels. It was pointed out that the Kelly study focused on chlorinated solvents and that the BTEX compounds targeted for the RI/FS are more ubiquitous and difficult to evaluate relative to typical background levels in indoor air in many homes. Mr. Villarreal indicated that he would provide PBW with a copy of the Kelly VI investigation report.

Mr. Pastor raised the question of whether ecological screening values should be used as the basis for determining the extent of contamination, the primary concern being that for some chemicals of concern such as certain metals in soil, ecological screening values are several orders of magnitude less than human health screening values and are not applicable in some cases such as adjacent industrial properties (e.g., salvage yards). Mr. Villarreal agreed that this question had merit and recommended the issue be discussed in a subsequent conference call with Mr. Shewmake (see below).

Project Scheduling

Mr. Villarreal asked about the approximate duration of the field efforts. Mr. Pastor described a phased approach to completing the RI as follows:

Off-site groundwater investigation – The off-site groundwater investigation would be completed first since the access issues will likely not be as difficult as for the Site, off-site groundwater quality and potential VI impacts are potentially significant concerns, and the approach represents an "outside-in" process that will help direct the focus of the on-site investigation. The off-site field work is expected to take about one week to complete, with analytical data available in about one month and validated data available within about two months.

On-site investigation- The on-site investigation is expected to take about 2 weeks to complete, with analytical data available within about one month and validated analytical data available within about two months.

Additional phases – Based on the results of the initial off-site and on-site investigation, additional phases may be proposed to generate site-specific background values or to conduct specialized investigations (e.g., vapor intrusion investigation).

Mr. Villarreal agreed that beginning with the off-site groundwater investigation was appropriate. Mr. Pastor suggested that August or September were reasonable estimates for when the field work would take place. Additional investigation phases could extend into 2011. Mr. Pastor indicated that the RI/FS Work Plan will contain a schedule based on many assumptions which may result in changes to the overall schedule as the project proceeds. EPA re-affirmed that there were no firm dates established yet and that the objective of the RI/FS was to complete the required work in a defensible manner that was goal oriented rather than timeline driven.

RI/FS Investigation

Mr. Villarreal indicated that an evaluation of VI impacts should be conducted on the groundwater data obtained from the off-site wells if the results were elevated. Mr. Nickels asked for clarification on what would constitute elevated levels warranting additional investigation. Mr. Villarreal suggested that the most recent VI screening levels consolidated from EPA Regions 3, 6, and 9 be used to screen the groundwater sampling results. Mr. Villarreal also commented that a 100-ft radius from the monitoring well was recommended in the EPA guidance as the area to be considered for VI impacts.

Potential Ecological Risk Questions

Mr. Pastor noted that there were several ecological risk questions that the group wanted to discuss. Mr. Villarreal suggested that Dr. Tyndall contact Kenneth Shewmake to set up a call and Mr. Villarreal would be happy to sit in. As a preview for that call, Mr. Pastor noted the following:

Ponded Water on the Site Mr. Shewmake had previously mentioned the possible need to sample ponded water occasionally present at the Site and evaluate it using an approach presented in a forthcoming EPA guidance document (Mr. Pastor said that he thought Mr. Shewmake had used the term “fly and die” evaluation when referring to this document).

Drainage Ditch Mr. Pastor indicated that another topic for discussion was the drainage ditch west of the Site. Mr. Pastor explained that a topographic survey of the Site indicates that the vast majority of surface water runoff from the Site is not towards the ditch, however, there is likely potential for runoff to the ditch from localized areas on the western perimeter of the Site. Mr. Villarreal recommended this subject be discussed with Mr. Shewmake and suggested that additional surface soils could be collected in the potential runoff areas. Mr. Pastor noted that a related question would be what criteria should be used to evaluate these samples and the potential contribution of contaminants, if any, to the ditch. Additional discussion followed regarding the amount of trash in the ditch, potential for up-stream sources of impairment, and whether the ditch should be considered viable ecological habitat.

Mr. Pastor suggested that, if needed, evaluation of the ditch be narrowly focused to avoid a drainage basin-wide evaluation that may include multiple off-site sources and areas. Mr. Pastor noted that previous Kelly investigations had concluded that the area/ditch was not habitat. Mr. Villarreal supported using the Kelly information in our assessment and to not include an evaluation of the ditch specifically unless Site data warranted an evaluation. Mr. Pastor agreed that this topic would be discussed in the call with Mr. Shewmake.

Several detailed questions regarding sampling methods and analytical requirements were raised by Mr. Nickels. Mr. Villarreal asked that these and other questions be submitted to him in an email

<u>Community Relations</u>

Mr. Villarreal indicated that EPA would be updating the Community Involvement Plan (CIP) for the Site. Mr. Pastor noted that previously Mr. Villarreal had indicated that the Site mailing list would be focused on the adjacent neighborhood. Mr. Villarreal confirmed that was still the objective. Mr. Pastor inquired about receiving the proposed mailing list for distribution of the CIP. EPA indicated that it may not be possible to provide the actual distribution list due to privacy restrictions; however, they will provide information that is permitted. Mr. Pastor requested the opportunity to review any community involvement information or fact sheets proposed for public distribution prior to release. Mr. Villarreal indicated that should be possible.

EPA indicated they would be working with the City of San Antonio to hold a general Health Fair in a neighborhood somewhere in the vicinity of the Site as part of an EPA outreach program. The Health Fair was described as general in nature and not intended to be associated with the R&H Site. PBW asked to be provided any information relating to the Site that might be included in the Health Fair prior to the Health Fair. Mr. Stephen Harper indicated the Health Fair was planned for around September 2010.

Mr. Villarreal provided City of San Antonio personnel contact information for obtaining clearance for monitoring well installations in City right of way. The logistics of drilling in City streets was discussed and included suggestions of distributing fliers to nearby residents to describe the planned activities (drilling technique, drilling equipment, noise, dust, and street closures) and anticipating school bus operations in the area. Use of bilingual communications as part of community relations activities was also discussed.

Mr. Pastor stated that the PRP group was continuing to provide regular Site maintenance and mowing at the Site. Mr. Villarreal indicated that EPA supports this activity and agrees that it is beneficial.

<u>Action Items</u>

1. Eric Pastor to provide Scoping Phase Meeting minutes to Chris Villarreal for review.
2. Chris Villarreal to provide distribution list with specific contacts and addresses.
3. Eric Pastor to provide Kelly background soil reports to Chris Villarreal.
4. Chris Villarreal to provide Kelly AFB monitoring data.
5. Chris Villarreal to Provide Kelly AFB VI investigation report.
6. Kirby Tyndall to contact Kenneth Shewmake directly to discuss ecological risk assessment issues.
7. Eric Pastor to send e-mail to Chris Villarreal with specific sampling questions.
8. EPA to provide health fair information to PRPs.
9. Chris Villarreal to check on ability to provide CIP mailing list to PRPs.

Attachment A

Meeting Attendee Sign in Sheet

R&H OIL/TROPICANA ENERGY COMPANY
PROJECT KICK-OFF MEETING
MARCH 24, 2010

NAME	REPRESENTING	CONTACT INFORMATION
Chris Villarreal Chris Villarreal	EPA – Remedial Project Manager	214-665-6758 villarreal.chris@epa.gov
Ruben Moya	EPA – Remedial Project Manager	214-665-2755 moya.ruben@epa.gov
Dipanjana Bhattacharya D Bhattacharya	EPA Human Health Risk Assessor	214-665-6753 bhattacharya.dipanjana@epa.gov
Stephen Harper Stephen Harper	EPA – Community Relations Coordinator	214-665-2727 Harper.stephen@epa.gov
Gary Miller G W Miller	EPA - RCRA	214 665 8306 miller.gary@epa.gov
Kathy Thomas	6PD-F	214-665-2229 thomas.kathryn@epa.gov
Tim Nickels	RHI DRP Group	512-671-3434 tim.nickels@PBWLLC.com

R&H OIL/TROPICANA ENERGY COMPANY
PROJECT KICK-OFF MEETING
MARCH 24, 2010

NAME	REPRESENTING	CONTACT INFORMATION
Eric Pastor [illegible]	Pastor, Behling & Wheeler, L.L.C	512-671-3434 eric.pastor@pbwllc.com
Robert J. Sterrett, Ph. D Robert J Sterrett	ITASCA DENVER, INC FLINT INK	303-969-8033 bsterrett~~@hci.com~~ @itascadenver.com
Mike Peters	Commercial Steel	
Kirby Tyndall Kirby Tyndall	Pastor, Behling & Wheeler, L.L.C	512-671-3434 Kirby.tyndall@pbwllc.com
~~Tim Nichols~~		
Michael Jones Michael Jones	PBW	(720) 341-1501 michael.jones@pbwllc.com

Attachment B

Bexar County Appraisal District Property Search Results and EPA Access Agreements

Bexar CAD

Property Search Results > 421668 PARTNERS TERMINAL CO INC for Year 2010

Property

Account

Property ID:	421668	Legal Description:	NCB 8730 BLK 4 LOT 16B, 16D 17B, 18B, 19B & P-100 PT OF FITCH ST
Geographic ID:	08730-004-0160	Agent Code:	
Type:	Real		

Location

Address:	507 SOMERSET RD TX	Mapsco:	649E5
Neighborhood:	NBHD code12680	Map ID:	
Neighborhood CD:	12680		

Owner

Name:	PARTNERS TERMINAL CO INC	Owner ID:	320520
Mailing Address:	507 SOMERSET RD SAN ANTONIO, TX 78211	% Ownership:	100.0000000000%
		Exemptions:	

Values

(+) Improvement Homesite Value:	+	N/A		
(+) Improvement Non-Homesite Value:	+	N/A		
(+) Land Homesite Value:	+	N/A		
(+) Land Non-Homesite Value:	+	N/A	Ag / Timber Use Value	
(+) Agricultural Market Valuation:	+	N/A		N/A
(+) Timber Market Valuation:	+	N/A		N/A

(=) Market Value:	=	N/A		
(–) Ag or Timber Use Value Reduction:	–	N/A		

(=) Appraised Value:	=	N/A		
(–) HS Cap:	–	N/A		

(=) Assessed Value:	=	N/A		

Taxing Jurisdiction

Owner: PARTNERS TERMINAL CO INC
% Ownership: 100.0000000000%
Total Value: N/A

Entity	Description	Tax Rate	Appraised Value	Taxable Value	Estimated Tax
06	BEXAR CO RD & FLOOD	N/A	N/A	N/A	N/A
08	SA RIVER AUTH	N/A	N/A	N/A	N/A
09	ALAMO COM COLLEGE	N/A	N/A	N/A	N/A
10	UNIV HEALTH SYSTEM	N/A	N/A	N/A	N/A
11	BEXAR COUNTY	N/A	N/A	N/A	N/A
21	CITY OF SAN ANTONIO	N/A	N/A	N/A	N/A
58	SOUTH SAN ISD	N/A	N/A	N/A	N/A
CAD	BEXAR APPRAISAL DISTRICT	N/A	N/A	N/A	N/A
	Total Tax Rate:	N/A			
				Taxes w/Current Exemptions:	N/A
				Taxes w/o Exemptions:	N/A

Improvement / Building

Improvement #1: Commercial **State Code:** F1 **Living Area:** sqft **Value:** N/A

Type	Description	Class CD	Exterior Wall	Year Built	SQFT
FEN	Fence	S		0	780.0

Land

#	Type	Description	Acres	Sqft	Eff Front	Eff Depth	Market Value	Prod. Value
1	CSS	Commercial Store Site	2.3000	100100.00	0.00	0.00	N/A	N/A

Roll Value History

Year	Improvements	Land Market	Ag Valuation	Appraised	HS Cap	Assessed
2010	N/A	N/A	N/A	N/A	N/A	N/A
2009	$7,720	$160,160	0	167,880	$0	$167,880
2008	$230,890	$160,160	0	391,050	$0	$391,050
2007	$220,810	$160,160	0	380,970	$0	$380,970
2006	$233,960	$120,120	0	354,080	$0	$354,080
2005	$199,300	$120,100	0	319,400	$0	$319,400

Deed History - (Last 3 Deed Transactions)

#	Deed Date	Type	Description	Grantor	Grantee	Volume	Page
1		Deed	Deed		PARTNERS TERMII	4255	0381

2010 data current as of Mar 21 2010 9:16PM.
2009 and prior year data current as of Mar 15 2010 8:55AM
For property information, contact (210) 242-2432 or (210) 224-8511 or email.
For website information, contact (210) 242-2500.

This year is not certified and ALL values will be represented with "N/A".

Website version: 1.2.2.2 Database last updated on: 3/21/2010 9:16 PM

This site only supports Internet Explorer 6+, Netscape 7+ and Firefox 1.5+.

Bexar CAD Property Search | Map Search | Map Administration | Login

Property Search Results > Property ID 421668 PARTNERS TERMINAL CO INC for Year 2010

New Search

Details | Map

Property Details

Account

Property ID:	421668
Geo. ID:	08730-004-0160
Type:	Real
Legal Description:	NCB 8730 BLK 4 LOT 16B, 16D 17B, 18B, 19B & P-100 FT OF FITCH ST

Location

Address:	507 SOMERSET RD TX
Neighborhood:	NBHD code12680
Mapsco:	649E5
Jurisdictions:	06, 08, 09, 10, 11, 21, 56, CAD

Owner

Name:	PARTNERS TERMINAL CO INC
Address:	507 SOMERSET RD SAN ANTONIO, TX 78211

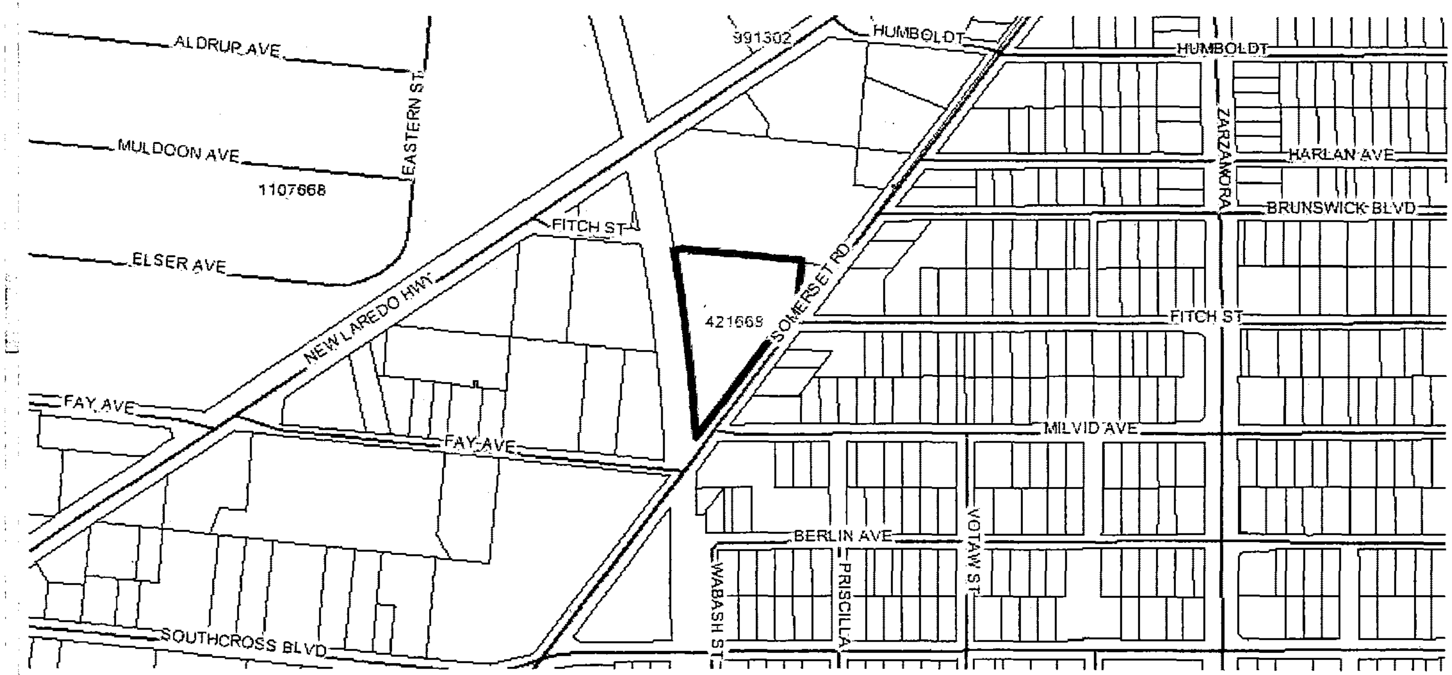
Property

Appraised Value: N/A

Map Layers

Radius Search

1: 5159 Zoom



TO: GARY W. MOORE -
FAX 214-665-7447

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 6
1445 ROSS AVENUE, SUITE 1200
DALLAS TEXAS 75202-2733

CONSENT FOR ACCESS TO PROPERTY

DESCRIPTION OF PROPERTY: The Partners Terminal Company, Inc. Property consisting of approximately 2.30 acres located at 419 Somerset Road with the legal description of Artesian Gardens Subdivision, New City Block (NCB) 8730, Block 4, Lots 16B, 16C, 16D, 17B, 18B, 19D, and P-100, San Antonio, Bexar County, Texas

I hereby consent, to the extent that I may have an interest, to officers, employees, and authorized representatives of the United States Environmental Protection Agency (EPA) entering and having continued access to the above described property for the following purposes:

1. The taking of samples, surface and subsurface, including but not limited to soil, sediments, water, and air, and other solids or liquids stored or disposed of at the property as may be determined to be necessary;

2. The taking of any and all records that may exist on-site;

3. Other investigative actions at the property as may be necessary to determine nature, extent and potential threat to human health and the environment; and,

4. The taking of such response action(s) as may be necessary to address any potential threat(s) to human health and the environment relative to the above identified property. The response action(s) will likely include removal and disposal of wastes materials in tanks, drums and equipment, surface and subsurface soil remediation. In addition, the response action(s) will include the demolition of onsite buildings, tanks, piping, and other equipment and the removal of such debris and equipment for disposal, scrap, or sale as determined appropriate by the EPA to cleanup the property. All proceeds from the sale or scrap of equipment will be credited to the response.

I realize that these actions are taken pursuant to EPA's response and enforcement responsibilities under the Comprehensive Environmental Response, Compensation, and Liability Act, as amended (CERCLA), 42 U.S.C. 9601 et seq.

I am a former Officer and Director of the dissolved company, Partners Terminal Company, Inc. I was unaware that I may have interest in this property until contacted by the EPA. I do not believe that I have the complete authority to provide access to this property. To the extent that I may have an interest in this property, I do not object to officers, employees, and authorized representatives of the United States Environmental Protection Agency (EPA) entering and having continued access to this property.

Name (Signature): [signature] Date: August 31-2000

Name (Print): J. KENT BURT Tel#:

Address: P.O. Box 35 Exeter Calif 93221

This Consent is given with the express understanding that it is not an admission of liability and cannot be used against me in any proceeding, administrative or judicial, at any time.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 6
1445 ROSS AVENUE, SUITE 1200
DALLAS TEXAS 75202-2733

CONSENT FOR ACCESS TO PROPERTY

DESCRIPTION OF PROPERTY: The Partners Terminal Company, Inc. Property consisting of approximately 2.30 acres located at 419 Somerset Road with the legal description of Artesian Gardens Subdivision, New City Block (NCB) 8730, Block 4, Lots 16B, 16C, 16D, 17B, 18B, and 19D, San Antonio, Bexar County, Texas

I do not object, to officers, employees, and authorized representatives of the United States Environmental Protection Agency (EPA) entering and having continued access to the above described property for the following purposes:

1. The taking of samples, surface and subsurface, including but not limited to soil, sediments, water, and air, and other solids or liquids stored or disposed of at the property as may be determined to be necessary;

2. The taking of any and all records that may exist on-site;

3. Other investigative actions at the property as may be necessary to determine nature, extent and potential threat to human health and the environment; and,

4. The taking of such response action(s) as may be necessary to address any potential threat(s) to human health and the environment relative to the above identified property. The response action(s) will likely include removal and disposal of wastes materials in tanks, drums and equipment, surface and subsurface soil remediation. In addition, the response action(s) will include the demolition of onsite buildings, tanks, piping, and other equipment and the removal of such debris and equipment for disposal, scrap, or sale as determined appropriate by the EPA to cleanup the property. All proceeds from the sale or scrap of equipment will be credited to the response.

I realize that these actions are taken pursuant to EPA's response and enforcement responsibilities under the Comprehensive Environmental Response, Compensation, and Liability Act, as amended (CERCLA), 42 U.S.C. 9601 et seq.

I am a former officer of Partners Terminal Company, Inc. and have no interest in this property or the tanks, drums, and other equipment on the property. I do not believe that I have the authority or the complete authority to provide access to this property. Although, I do not object, to officers, employees, and authorized representatives of the United States Environmental Protection Agency (EPA) entering and having continued access to this property.

Name (Signature): ________ Date: 8-22-00

Name (Print): W. L. Walstrott Tel#: ________

Address: 339 W Calif Blvd
Pasadena CA 91105

Bexar CAD

Property Search Results > 421575 T C GOLDEN INC for Year 2010

Property

Account

Property ID:	421575	Legal Description:	NCB 8727 BLK 2 LOTS 21,22 23,24A, AND P-100
Geographic ID:	08727-002-0221	Agent Code:	
Type:	Real		

Location

Address:	403 SOMERSET RD TX	Mapsco:	649E5
Neighborhood:	NBHD code12680	Map ID:	
Neighborhood CD:	12680		

Owner

Name:	T C GOLDEN INC	Owner ID:	320446
Mailing Address:	PO BOX 790594 SAN ANTONIO, TX 78279-0594	% Ownership:	100.0000000000%
		Exemptions:	

Values

(+) Improvement Homesite Value:	+	N/A	
(+) Improvement Non-Homesite Value:	+	N/A	
(+) Land Homesite Value:	+	N/A	
(+) Land Non-Homesite Value:	+	N/A	Ag / Timber Use Value
(+) Agricultural Market Valuation:	+	N/A	N/A
(+) Timber Market Valuation:	+	N/A	N/A
(=) Market Value:	=	N/A	
(–) Ag or Timber Use Value Reduction:	–	N/A	
(=) Appraised Value:	=	N/A	
(–) HS Cap:	–	N/A	
(=) Assessed Value:	=	N/A	

Taxing Jurisdiction

Owner: T C GOLDEN INC
% Ownership: 100.0000000000%
Total Value: N/A

Entity	Description	Tax Rate	Appraised Value	Taxable Value	Estimated Tax
06	BEXAR CO RD & FLOOD	N/A	N/A	N/A	N/A
08	SA RIVER AUTH	N/A	N/A	N/A	N/A
09	ALAMO COM COLLEGE	N/A	N/A	N/A	N/A
10	UNIV HEALTH SYSTEM	N/A	N/A	N/A	N/A
11	BEXAR COUNTY	N/A	N/A	N/A	N/A
21	CITY OF SAN ANTONIO	N/A	N/A	N/A	N/A
58	SOUTH SAN ISD	N/A	N/A	N/A	N/A
CAD	BEXAR APPRAISAL DISTRICT	N/A	N/A	N/A	N/A
	Total Tax Rate:	N/A			
				Taxes w/Current Exemptions:	N/A

Taxes w/o Exemptions: N/A

Improvement / Building

Improvement #1: Commercial **State Code:** F2 **Living Area:** 975.0 sqft **Value:** N/A

Type	Description	Class CD	Exterior Wall	Year Built	SQFT
305	IND BLDG LIGHT MFCTR	S	ME	1948	975.0

Improvement #2: Commercial **State Code:** F2 **Living Area:** 546.0 sqft **Value:** N/A

Type	Description	Class CD	Exterior Wall	Year Built	SQFT
400	OFFICE	C	CB	1960	546.0

Improvement #3: Commercial **State Code:** F2 **Living Area:** sqft **Value:** N/A

Type	Description	Class CD	Exterior Wall	Year Built	SQFT
FEN	Fence	S		0	712.0

Improvement #4: Commercial **State Code:** F2 **Living Area:** sqft **Value:** N/A

Type	Description	Class CD	Exterior Wall	Year Built	SQFT
CON	Concrete	*		0	3000.0

Land

#	Type	Description	Acres	Sqft	Eff Front	Eff Depth	Market Value	Prod. Value
1	IND	Industrial	3.9200	170755.00	0.00	0.00	N/A	N/A

Roll Value History

Year	Improvements	Land Market	Ag Valuation	Appraised	HS Cap	Assessed
2010	N/A	N/A	N/A	N/A	N/A	N/A
2009	$100	$256,130	0	256,230	$0	$256,230
2008	$100	$256,130	0	256,230	$0	$256,230
2007	$100	$256,130	0	256,230	$0	$256,230
2006	$17,100	$128,070	0	145,170	$0	$145,170
2005	$485,900	$128,100	0	614,000	$0	$614,000

Deed History - (Last 3 Deed Transactions)

#	Deed Date	Type	Description	Grantor	Grantee	Volume	Page
1		Deed	Deed		T C GOLDEN INC	4752	1655

2010 data current as of Mar 21 2010 9:16PM.
2009 and prior year data current as of Mar 15 2010 8:55AM
For property information, contact (210) 242-2432 or (210) 224-8511 or email.
For website information, contact (210) 242-2500.

Website version: 1.2.2.2

Database last updated on: 3/21/2010 9:16 PM

This site only supports Internet Explorer 6+, Netscape 7+ and Firefox 1.5+.

Bexar CAD Property Search | Map Search | Map Administration | Login

Property Search Results > **Property ID 421575 T C GOLDEN INC for Year 2009**

New Search

Details | Map

Property Details

Account

Property ID: 421575

Geo. ID: 08727-002-0221

Type: Real

Legal Description: NCB 8727 BLK 2 LOTS 21,22 23,24A, AND P-100

Location

Address: 403 SOMERSET RD TX

Neighborhood: NBHD code12580

Mapsco: 649E5

Jurisdictions: 06, 08, 09, 10, 11, 21, 56, CAD

Owner

Name: T C GOLDEN INC

Address: PO BOX 790594
SAN ANTONIO, TX 78279-0594

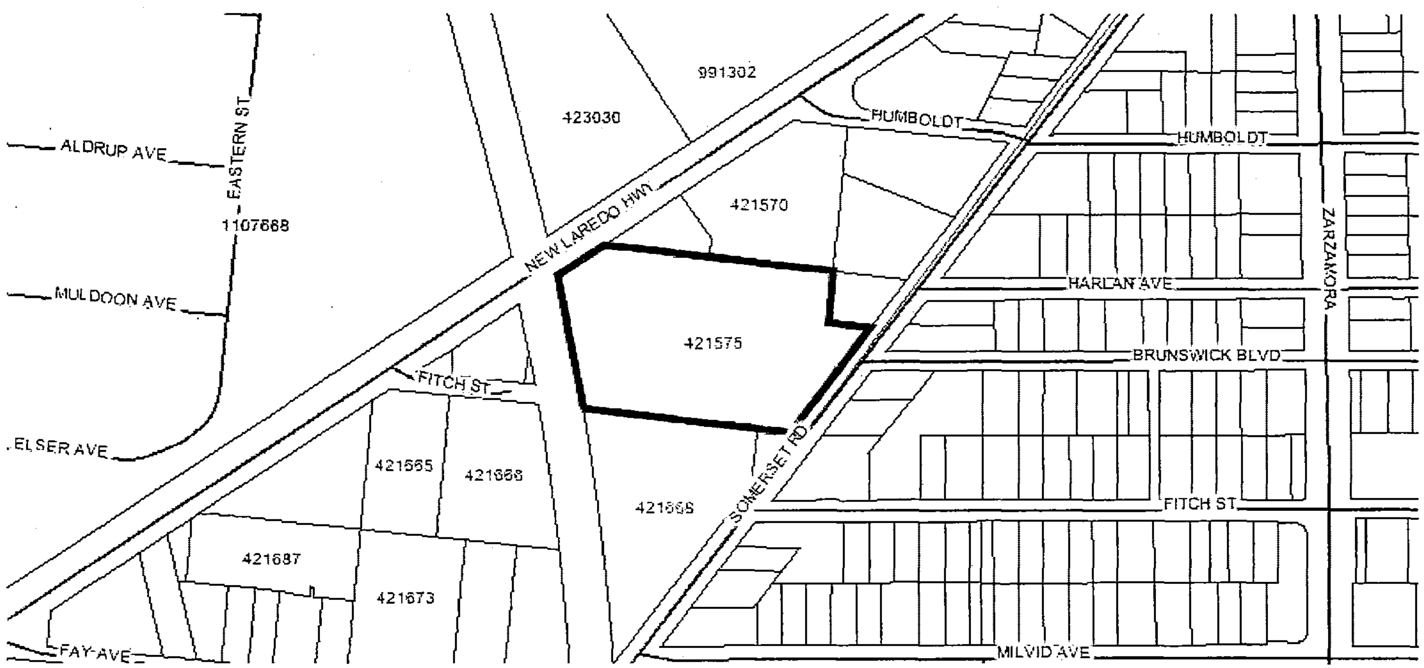
Property

Appraised Value: $256,220

Map Layers

Radius Search

1: 3769 Zoom



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 6
1445 ROSS AVENUE, SUITE 1200
DALLAS, TEXAS 75202-2733

CONSENT FOR ACCESS TO PROPERTY

Name of property owner: T.C. Golden, Inc.

Description of property (including address): 3.92 acres located at 403 Somerset Road with the legal description of New City Block (NCB) 8727, Block 2, Lots 21, 22, 23, 24A, and Street Lot P-100, San Antonio, Bexar County, Texas.

United States Environmental Protection Agency Region 6
1445 Ross Avenue, Suite 1200
Dallas, Texas 75202-2733

Consent for Entry and Access to Property

I hereby consent to officers, employees and parties authorized by the United States Environmental Protection Agency ("EPA"), entering and having continued access to the property described above at reasonable times for the following purposes:

1. The taking of samples, surface and subsurface, including but not limited to soil, sediments, water, and air samples, and other solids or liquids stored or disposed of at the property as may be determined necessary;

2. Other investigative actions at the property as may be necessary to determine the nature and extent of potential threat to human heath and the environment; and

3. The taking of such response actions as may be necessary to remediate the threat of releases of hazardous substances from the site and address any potential threats to human health and the environment.

4. I further understand that the response actions will likely include removal and disposal of waste materials in tanks, drums, and equipment, asbestos abatement, surface and subsurface soil remediation. The response actions will also consist of demolition of onsite tanks, piping, and other equipment as necessary to alleviate the threat to human health

215615

and the environment. The demolition will also include the removal of such debris and equipment for disposal, scrap, or sale as determined to be appropriate by the EPA.

I realize that these actions are undertaken pursuant to EPA's response and enforcement responsibilities under the Comprehensive Environmental Response, Compensation, and Liability Act ("CERCLA"), 42 U.S.C. Sections 9601-9675.

This written permission is given by me voluntarily with the knowledge of my right to refuse and without threats or promises of any kind.

I consent to this access agreement only to the extent that I have the legal authority to do so. My relationship to the property is as the Independent Executrix of the Estate of Mr. Andrew Sanchez Jr. Andrew Sanchez, Jr. was the sole Officer and Director of TC Golden, Inc., a Texas Corporation, which Corporation acquired the property by way of foreclosure. TC Golden, Inc., was voluntarily dissolved on July 28, 1998, by reason of filing Articles of Dissolution with the Secretary of State of the State of Texas. Notwithstanding the voluntary dissolution of T.C. Golden, Inc., that company remains the property owner of record on the above-listed parcel, and holds such title for the benefit of the creditors of TC Golden, Inc., as is stated in the Articles of Dissolution.

Date: 4-16-07

Signature: Margaret Sanchez

Print Name: MARGARET SANCHEZ

Address: PO BOX 312372

NEW BRAUNFELS, TX 78131

Phone Number: 830-609 1090

Attachment C

EPA Meeting Presentation Slides

R&H Oil/Tropicana Energy Project Kick-Off Meeting

March 24, 2010

EPA Dallas Office

Bexar CAD

Property Search Results > 421668 PARTNERS TERMINAL CO INC for Year 2010

Property

Account

Property ID:	421668	Legal Description:	NCB 8730 BLK 4 LOT 16B, 16D 17B, 18B, 19B & P-100 PT OF FITCH ST
Geographic ID:	08730-004-0160	Agent Code:	
Type:	Real		

Location

Address:	507 SOMERSET RD TX	Mapsco:	649E5
Neighborhood:	NBHD code12680	Map ID:	
Neighborhood CD:	12680		

Owner

Name:	PARTNERS TERMINAL CO INC	Owner ID:	320520
Mailing Address:	507 SOMERSET RD SAN ANTONIO, TX 78211	% Ownership:	100.0000000000%

Partners Terminal

- J. Kent Burt
- PO Box 35
- Exeter, CA 93221

- W.L. Martin
- 339 W. Califoirnia Blvd.
- Pasadena, CA 91105

- 1497 E. Marinette Ave.
- Exeter, CA 93221

Bexar CAD

Property Search Results > 421575 T C GOLDEN INC for Year 2010

Property

Account

Property ID:	421575	Legal Description:	NCB 8727 BLK 2 LOTS 21,22 23,24A, AND P-100
Geographic ID:	08727-002-0221	Agent Code:	
Type:	Real		

Location

Address:	403 SOMERSET RD TX	Mapsco:	649E5
Neighborhood:	NBHD code12680	Map ID:	
Neighborhood CD:	12680		

Owner

Name:	T C GOLDEN INC	Owner ID:	320446
Mailing Address:	PO BOX 790594 SAN ANTONIO, TX 78279-0594	% Ownership:	100.0000000000%

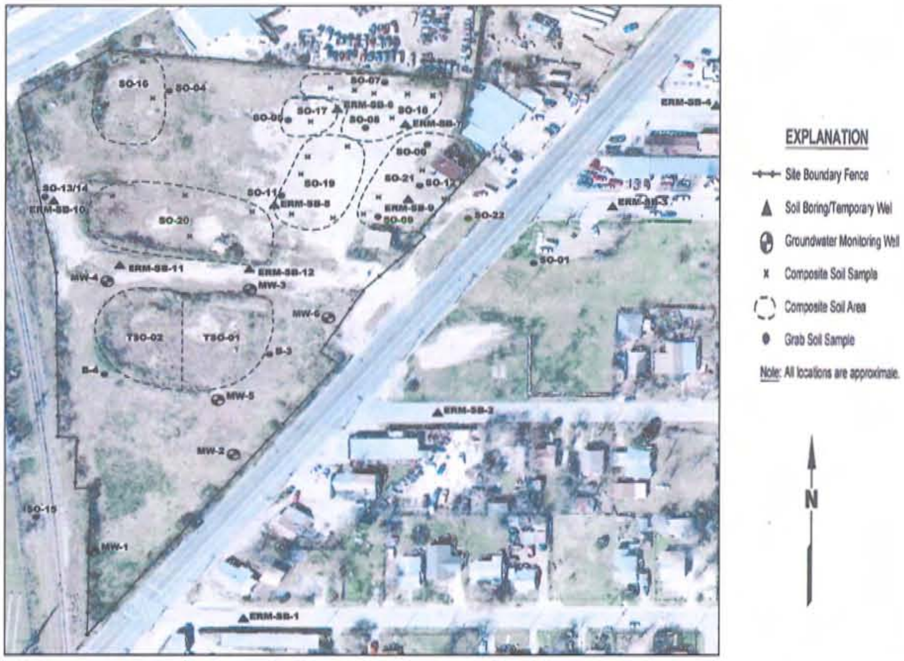
Margaret Sanchez
PO Box 312372
New Braunfels, TX 78181
830-609-1090

Schedule of Deliverables

Due with 60 days after Scoping Phase Meeting

- RI/FS Site Health and Safety Plan
- Draft RI/FS Work Plan
- Draft RI/FS Sampling and Analysis Plan

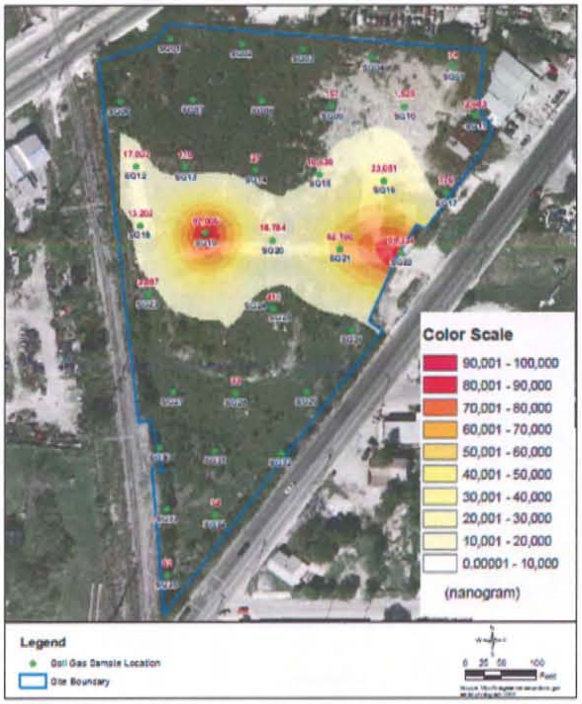
Scoping Phase Meeting – 3/24/2010
Deliverables due – 5/24/2010



R&H Oil/Tropicana

Passive Soil Gas Survey

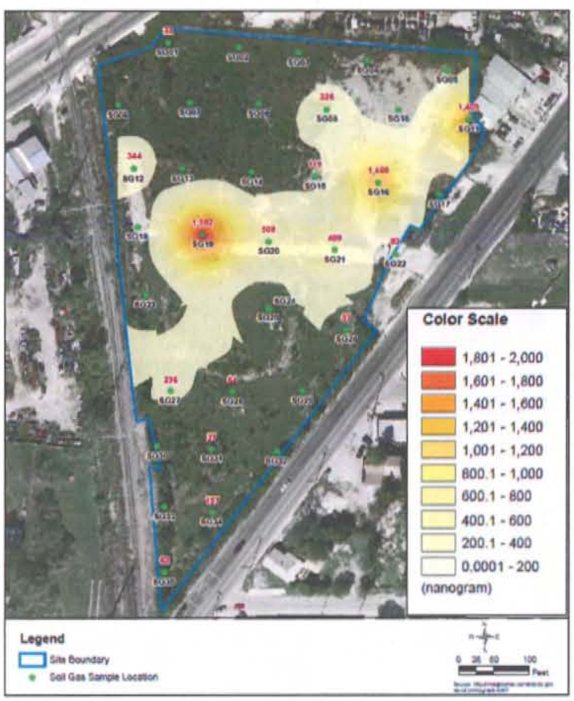
Passive Soil Gas Sampling Locations



R&H Oil/Tropicana

Passive Soil Gas Survey

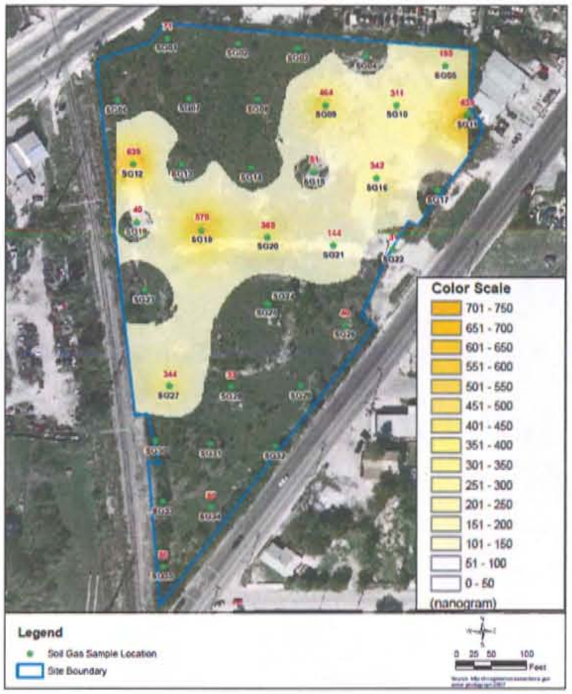
Benzene, Toluene, Ethylbenzene, and Xylenes Concentrations



R&H Oil/Tropicana

Passive Soil Gas Survey

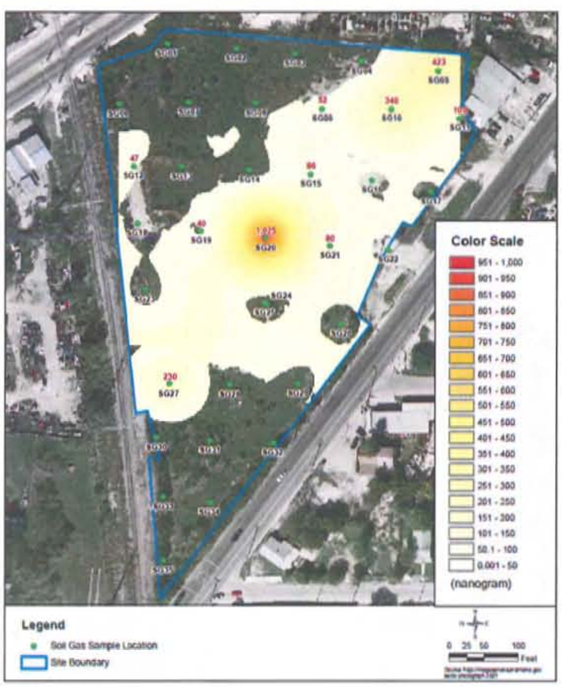
2-Methylnaphthalene Concentrations



R&H Oil/Tropicana

Passive Soil Gas Survey

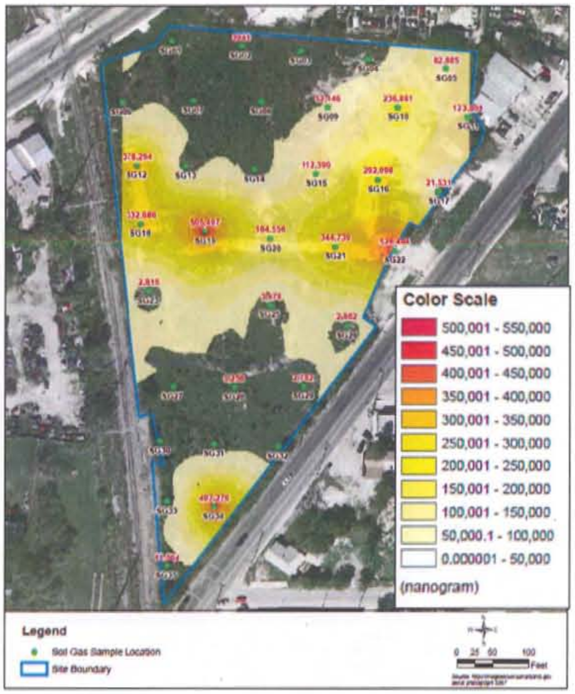
Naphthalene Concentrations



R&H Oil/Tropicana

Passive Soil Gas Survey

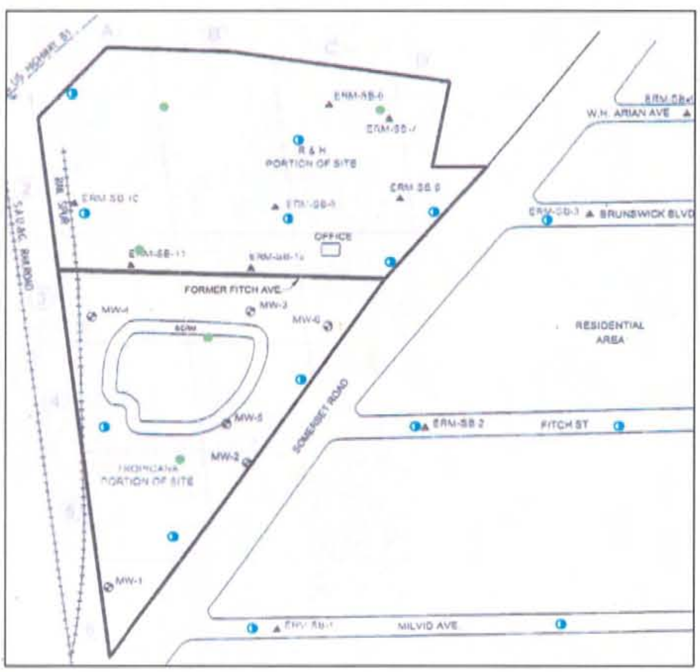
Acenaphthalene Concentrations



R&H Oil/Tropicana

Passive Soil Gas Survey

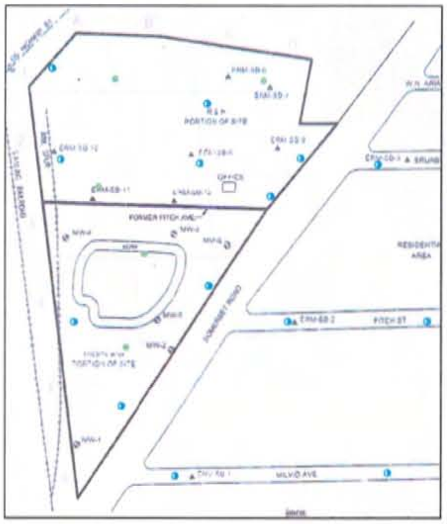
Total Petroleum Hydrocarbons (C5-C15) Concentrations

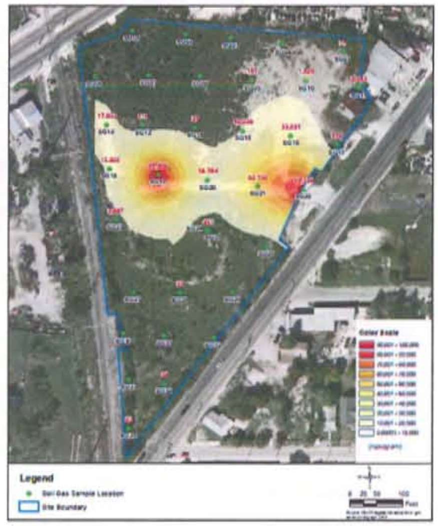


EXPLANATION

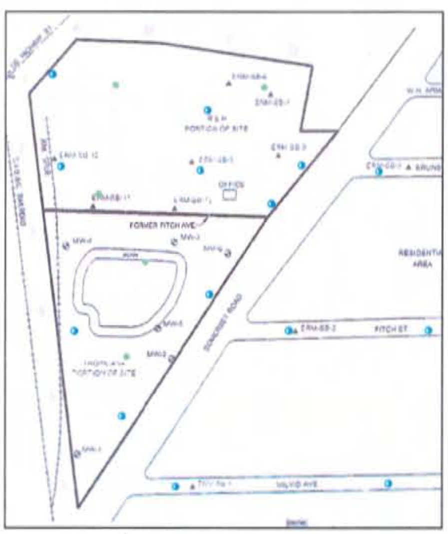
- Previous Soil Boring/Temporary Well Location
- Existing Groundwater Monitoring Well Location
- RI/FS Soil Boring/Groundwater Monitoring Well Location
- RI/FS Soil Boring/LNAPL Monitoring Well Location

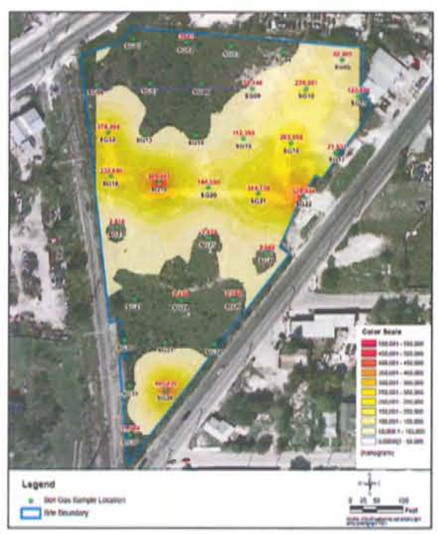
Revise RI/FS Sampling Locations Using Results of Passive Soil Gas Survey





Revise RI/FS Sampling Locations Using Results of Passive Soil Gas Survey





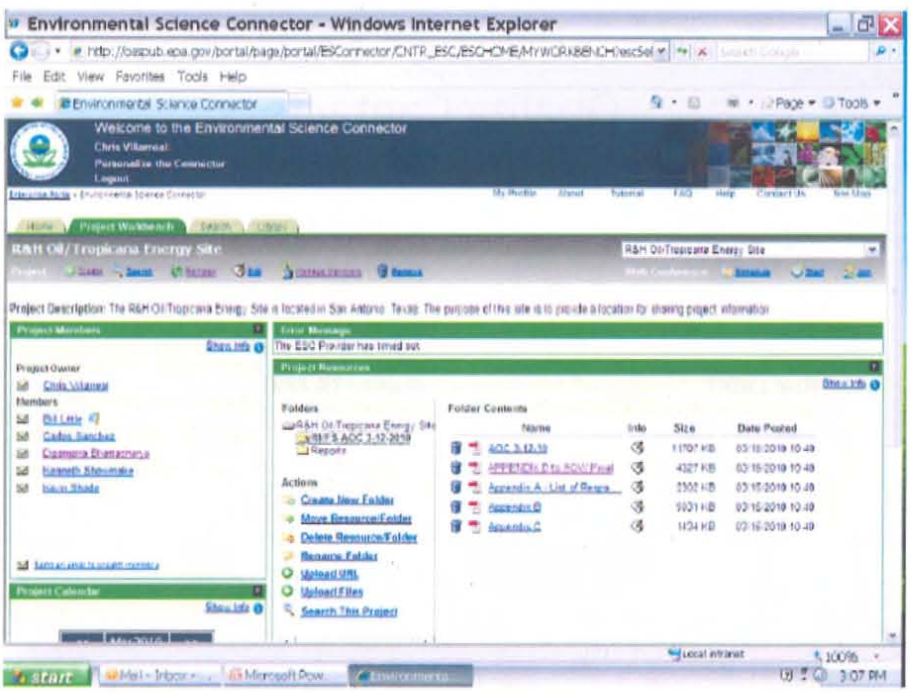
Selected Former East Kelly AFB Groundwater Monitoring Wells

EXPLANATION

Approx. Site Boundary

Groundwater Monitoring Well

Note: All locations are approximate.



EPA Contacts

Chris Villarreal
Remedial Project Manager
Superfund Division (6SF-RA)
1445 Ross Avenue, Suite 1200
Dallas, TX 75202-2733
villarreal.chris@epa.gov
214-665-6758
214-448-8670 (cell phone)

Dipanjana Bhattacharya
Human Health Risk Assessor
Bhattacharya.Dipanjana@epa.gov
214-665-6753

Stephen Harper
Community Relations Coordinator
Harper.Stephen@epa.gov
214-665-2727

Kenneth Shewmake
Ecological Risk Assessor
Shewmake.Kenneth@epa.gov
214-665-3198

Texas Commission on Environmental Quality Contacts

Marilyn Long
Project Manager
Superfund Section
(MC-136)
P.O. Box 13087
Austin, TX 78711-3087
mlong@tceq.state.tx.us
512-239-2450

Richard Seiler
Natural Resource Trustee Program
(MC 133)
P.O. Box 13087
Austin, TX 78711-3087

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 6
1445 Ross Avenue, Suite 1200
Dallas, Texas 75202-2733

April 9, 2010

Mr. Eric Pastor, P.E.
Pastor, Behling & Wheeler, LLC
2201 Double Creek Drive, Suite 4004
Round Rock, TX 78664

Re: R&H Oil/Tropicana Energy Site
EPA Scoping Phase Meeting Minutes

Dear Mr. Pastor:

Thank you for providing the meeting minutes from the EPA Scoping Phase Meeting held at the EPA offices in Dallas on March 24, 2010. The purpose of this letter is to serve as a follow-up to the listed action items and to provide clarification to the meeting minutes.

1. <u>Deliverables, page 1 of 5</u>

In response to the request that agency recipients of deliverables be identified (i.e., by name), please provide deliverables to the following parties:

- US EPA Region 6
  Attn: Chris Villarreal
  Superfund Division (6SF-RA)
  1445 Ross Avenue, Suite 1200
  Dallas TX 75202-2733

- Texas Commission on Environmental Quality
  Attn: Marilyn Long, Project Manager
  Superfund Section (MC-136)
  P.O. Box 13087
  Austin, TX 78711-3087

- Texas Commission on Environmental Quality
  Attn: Richard Seiler
  Natural Resource Trustee Program (MC 133)
  P.O. Box 13087
  Austin, TX 78711-3087

At this time, the EPA has not procured the services of an Oversight Contractor for the R&H Oil/Tropicana Energy site. If one is procured, you will be provided their contact information. If additional Natural Resource Trustees require deliverables, you will also be provided their contact information.

2. <u>Project Data, page 2 of 5, second paragraph</u>

Text states, "*Ms. Dipanjana Bhattacharya requested that any time values from the Kelly background study are used in the risk assessment or for comparison to background concentrations, that the values being used from the Kelly study be included*."

In addition to the values, also include the date the data was collected.

3. <u>RI/FS Investigation, page 4 of 5</u>

Text states, "*Mr. Villarreal also commented that a 100-ft radius from the monitoring well was recommended in the EPA guidance as the area to be considered for VI impacts*."

Vapor intrusion (VI) is a potential concern at any building – existing or planned – located near soil and/or groundwater contaminated with toxic chemicals that can volatilize. Relatively low concentrations in soil or groundwater may pose a risk for VI. Many variables may affect VI including, but not limited to, site current and/or potential land use, contaminant concentration, soil type and degree of heterogeneity, building construction and condition, depth of contamination, and seasonal variation.

EPA draft 2002 VI guidance (http://epa.gov/osw/hazard/correctiveaction/eis/vapor/complete.pdf) defines "near" as volatile or toxic compounds within 100 feet (laterally or vertically) of buildings unless there is conduit that intersects the migration route that would allow soil gas to migrate further than 100 feet. The guidance defines a conduit as any passageway that could facilitate flow of soil gas including porous layers such as sand or gravel, buried utility lines or animal burrows. The 100-foot distance may not be appropriate in all cases. If the contaminant plume is not well defined, it may be necessary to evaluate potential pathways from a distance greater than 100 feet.

4. **<u>Potential Ecological Risk Questions, page 5 of 5</u>**

Text states, "*Mr. Villarreal supported using Kelly information in our assessment and not include an evaluation of the ditch specifically unless Site data warranted an evaluation*."

In regards to Kelly AFB data, enclosed please find a CD with a pdf copy of the Final Zone Ecological Risk Assessment Report (CH2M Hill, March 2004). A copy of this report has also been uploaded to the R&H Oil/Tropicana Energy Environmental Science Connector web site. Included as an attachment to this report is a Technical Memorandum - Development of

Groundwater Background Values Zone 4 RFI, Kelly AFB, Texas. In addition, pdf copies of documents generated during the Kelly AFB vapor intrusion work including a 41.7 MB file (Kelly VI Studies 2 of 2 from Gary Miller – 0323-dfa-gcms-062008) are also provided. This file was too large to send by email.

In regards to the background study for inorganics for all of Kelly AFB, a report was completed in March 1994. There was an addendum dated October 1999 which was conditionally approved by the Texas Commission on Environmental Quality in January 2000. The Kelly AFB Administrative Record website at https://afrpaar.lackland.af.mil/ar/docsearch.aspx has these documents as AR# 436, 1823 and 1868.

In regards to the evaluation of the ditch, this subject should be discussed with Mr. Shewmake.

5. <u>Community Relations, page 5 of 5</u>

In regards to the request to provide the site's actual mailing list, I was informed that this information is not releasable.

Text states, "*Mr. Pastor requested the opportunity to review any community involvement information or fact sheets proposed for public distribution prior to release. Mr. Villarreal indicated that should be possible*."

As discussed in Appendix B (Statement of Work) of the Administrative Settlement Agreement and Order on Consent for Remedial Investigation/Feasibility Study, Task 5 (Community Relations, page 12), "***As appropriate and feasible****, EPA will provide Respondents with the opportunity to review and provide comments on a draft community relations plan, including the stakeholder and community mailing lists, and fact sheets prior to distribution*."

In regards to the general Health Fair, EPA has learned that the City of San Antonio will be holding a Heath Fair in August. Since the City is holding this event, the EPA will not be working to set one up.

6. <u>Action Items, page 5 of 5</u>

The following is the list of Action Items listed in the meeting minutes and completion status:

1. <u>Eric Pastor to provide Scoping Phase Meeting minutes to Chris Villarreal for review.</u>
   COMPLETED

2. <u>Chris Villarreal to provide distribution list with specific contacts and addresses.</u>
   COMPLETED
   Additional contacts may be added as discussed in Comment 1.

3. Eric Pastor to provide background soil reports to Chris Villarreal.
COMPLETED
As attachments to a 04/08/2010 email, Eric Pastor provided the following documents:

- Texas Natural Resource Conservation Commission conditional approval letter dated January 18, 2000 of the *Final Report – Addendum to Final Background Levels of Inorganics in Soils at Kelly AFB* dated October 1999.
- *Final Report Addendum to Final Background Levels of Inorganics in Soil at Kelly AFB* (October 1999).
- *Final* [Report] *Background Levels of Inorganics in Soils at Kelly Air Force Base* (March 1994).

These documents have been added to the Superfund Document Management System for the R&H Oil/Tropicana Energy Site.

4. Chris Villarreal to provide Kelly AFB monitoring data.
COMPLETED

5. Chris Villarreal to provide Kelly AFB VI investigation report.
COMPLETED
Documents generated during the Kelly AFB VI investigation are provided on the enclosed CD.

6. Kirby Tyndall to contact Kenneth Shewmake directly to discuss ecological questions.
COMPLETED
Conference call held on 04/05/2010.

7. Eric Pastor to send e-mail to Chris Villarreal with specific sampling questions.
TO BE COMPLETED

8. EPA to provide health fair information to PRPs.
COMPLETED
See comment 5 (Community Relations, page 5 of 5) above.

9. Chris Villarreal to check on ability to provide CIP mailing list to PRPs.
COMPLETED
See comment 5 (Community Relations, page 5 of 5) above.

If you have any comments or questions, please feel free to contact me by telephone at 214-665-6758 or by email at villarreal.chris@epa.gov.

Sincerely,

Chris Villarreal
Remedial Project Manager
Superfund Division

Enclosure (1)

Tim Nickels

From: Kirby Tyndall
Sent: Thursday, April 08, 2010 1:38 PM
To: Shewmake.Kenneth@epamail.epa.gov
Cc: Villarreal.Chris@epamail.epa.gov; Eric Pastor; Michael Jones; Tim Nickels; Jane Alder
Subject: RE:

Hi Kenneth,

Thank you for your comments and response.

I realized that I incorrectly wrote in my email below that the ponded surface water on site is perennial. It is not perennial but ephemeral and is only there after a rain event. I just wanted to clarify that. Sorry!

Have a great afternoon!
Kirby

From: Shewmake.Kenneth@epamail.epa.gov [mailto:Shewmake.Kenneth@epamail.epa.gov]
Sent: Monday, April 05, 2010 4:37 PM
To: Kirby Tyndall
Cc: Villarreal.Chris@epamail.epa.gov; Eric Pastor; Michael Jones; Tim Nickels
Subject: Re:

Kirby,

I would like to see a comparison of soil, surface water, and sediment values to TCEQ ecological benchmarks (RG-263). We need to complete step 1 and 2 of the 8 step ERA process as outlined in the EPA ERA guidance from 1997. If we can document that the habitat is limited due to the urban, industrial nature of the site, and if the data shows that the site is not a risk to migrating receptors, then we will probably decide that a full 8 step BERA is not needed. In order to demonstrate that the site is not a hazard for migrating receptors, it would be good to show that media values do not exceed LD50 acute toxicity values. I would like to see a comparison of the values that exceed TCEQ benchmarks, to LD50 values to show that this is not an issue. This is not a substitute for a comparison to screening benchmark values.

The other issues discussed in the meeting minutes are acceptable.

We need to see a map of the background sample locations in order to use the Kelly background data. Chris was going to see if he had this information.

Kenneth Shewmake
US EPA, 6SF-TR
1445 Ross Ave., Suite 1200
Dallas, TX 75202-2733
(214)665-3198

From: "Kirby Tyndall" <kirby.tyndall@pbwllc.com>
To: Kenneth Shewmake/R6/USEPA/US@EPA, Chris Villarreal/R6/USEPA/US@EPA
Cc: "Michael Jones" <michael.jones@pbwllc.com>, "Eric Pastor" <eric.pastor@pbwllc.com>, "Tim Nickels" <tim.nickels@pbwllc.com>
Date: 04/05/2010 02:23 PM
Subject:

Hi! Thank you for taking the time to talk with Michael Jones and myself this morning about the R&H site. The following represents our discussion to the best of my understanding so please let me know if I've misrepresented anything.

We discussed the "fly and die scenario" guidance that EPA had previously been working on for small sites in industrial areas, such as R&H. It represented more of an acute exposure scenario for sites that have marginal habitat. While the guidance will not be issued any time soon, if ever, we can still use the premise of it and compare site soil concentrations to an acute or LD50-type threshold, as opposed to soil screening levels that are based on more conservative, chronic measurements of toxicity. Given the perennial nature of the ponded rainwater on site (which is the only surface water on-site), sampling ponded surface water will not be required in the RI as had been discussed in previous conversations about the Site (over a year ago).

The newer Kelly data will be used for background comparison if it is determined by EPA that the data is of high enough quality. Chris felt like it would be of high enough quality given that it is fairly recent and was collected during a rigorous investigation. Chris passed on the Kelly data to Dipanjana and Kenneth.

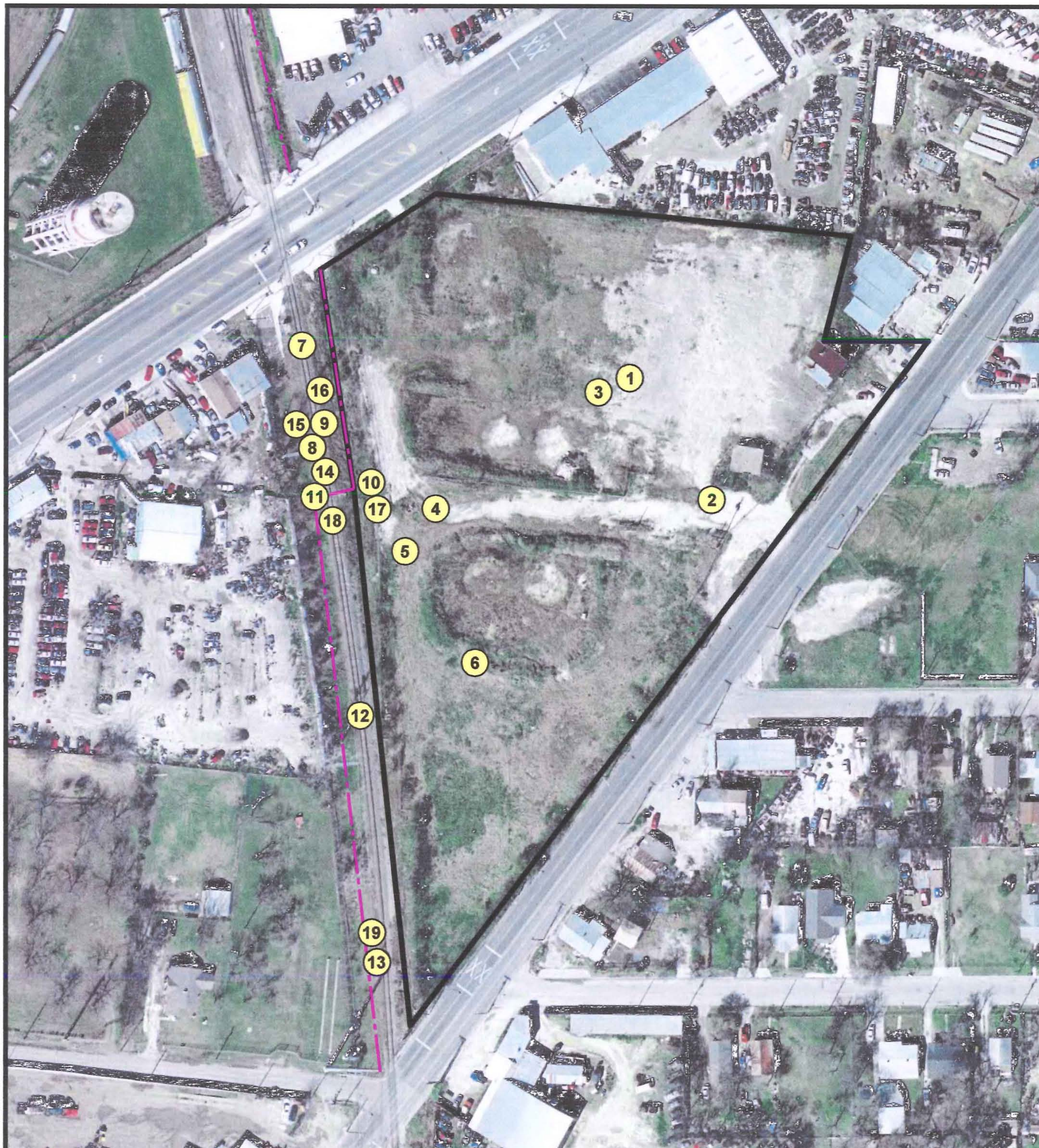
Since there is a potential transport pathway for the site-related compounds to have migrated from the Site to the ditch adjacent to the Site, Kenneth would like for us to collect three sediment and three surface water samples in the ditch, as well as three background samples from a similar but upstream location. Kirby will send Kenneth the topographic map of the Site. It is recognized that the ditch data will be difficult to evaluate in regards to site-related contamination but, regardless, it will be compared to TCEQ surface water and sediment benchmarks. If it is possible to show that it is not ecological habitat due to the perennial nature of the ditch, these data may not be necessary. Michael discussed collecting soil samples on the downward slope leading into the ditch to see if site-related compounds are measured there as additional information about potential contaminant migration. Kenneth indicated that more information about site conditions is helpful so he would be in favor of collecting these data too.

Again, thank you for your time.

Kirby Tyndall, Ph.D., DABT
Senior Consulting Toxicologist
Pastor, Behling & Wheeler, LLC
512 671-3434

APPENDIX B

SITE PHOTOGRAPHS



EXPLANATION

Approx. Site Boundary

Drainage Ditch

(1) Denotes Approximate Location of Corresponding Photograph

N

Approx. Scale in Feet

0 75 150

Source:
http://imageserver.sanantonio.gov aerial photograph, 8/19/03.

R&H OIL/TROPICANA ENERGY SITE		
Figure B-1 **SITE PHOTOGRAPH LOCATION MAP**		
PROJECT: 1589	BY: ZGK	REVISIONS
DATE: SEPT., 2010	CHECKED: EFP	
PASTOR, BEHLING & WHEELER, LLC CONSULTING ENGINEERS AND SCIENTISTS		

Photograph 1. North part of Site, standing near center looking East (April 20, 2006).

Photograph 2. North part of Site, standing near gate looking North/North-West to adjacent property (October 2, 2009).

Photograph 3. North part of Site, standing near center looking West (October 2, 2009).

Photograph 4. Southern portion of the Site, looking East prior to a mowing event (October 2, 2009).

Photograph 5. Southern portion of the Site, looking South along fenceline on western side of property prior to a mowing event (October 2, 2009).

Photograph 6. On south side of berm on southern portion of the Site, looking North property prior to a mowing event (October 2, 2009).

Photograph 7. Looking North along ditch that runs on both sides of railroad tracks, just West of the Site (April 20, 2006).

Photograph 8. Ditch running on the west-side of railroad tracks and east of junk yard, just before the culvert that connects the two sides of the ditch near Former Fitch Avenue (April 20, 2006).

Photograph 9. Looking North along ditch, West of the Site (April 20, 2006).

Photograph 10. Culvert in ditch, under railroad tracks that connects ditch near Site with ditch on other side of tracks (April 20, 2006).

Photograph 11. Ditch on western side of railroad tracks, looking South from culvert (April 20, 2006).

Photograph 12. On railroad tracks on western side (fenceline to right), looking North. Ditch has passed through culvert and is on the left side of the track. April 20, 2006.

Photograph 13. Southern tip of the ditch, looking South (April 20, 2006).

Photograph 14. Similar view as Photograph 7 but further south on railroad tracks. Looking North along ditch that runs on both sides of railroad tracks, just West of the Site (August 31, 2010).

Photograph 15. Ditch running on the west-side of railroad tracks and east of junk yard, before the culvert that connects the two sides of the ditch near Former Fitch Avenue (August 31, 2010). Similar view to Photograph 8 but further north.

Photograph 16. Looking North along ditch, West of the Site (August 31, 2010). Similar view as Photograph 9.

Photograph 17. Culvert in ditch, under railroad tracks that connects ditch near Site with ditch on other side of tracks (August 31, 2010). Same view as Photograph 10.

Photograph 18. Ditch on western side of railroad tracks, looking South from culvert (August 31, 2010). Same view as Photograph 11.

Photograph 19. Southern tip of the ditch, looking South (August 31, 2010). Same view as Photograph 13.

APPENDIX C

US FISH AND WILDLIFE LETTER REGARDING PROTECTED AND ENDANGERED SPECIES AT KELLY AIR FORCE BASE

United States Department of the Interior

FISH AND WILDLIFE SERVICE
10711 Burnet Road, Suite 200
Austin, Texas 78758
512 490-0057
FAX 490-0974

DEC 14 2004

Andrew J. Chartrand
CH2M HILL
7600 West Tidwell Road
Suite 600
Houston, Texas 77040

Consultation # 2-15-05-I-0062

Dear Mr. Chartrand:

Thank you for your November 19, 2004, inquiry about possible environmental impacts from your planned project in San Antonio, Bexar County, Texas. We understand that you are conducting an ecological risk assessment for Kelly Air Force Base. A project description was not provided. Due to the volume of requests that we receive and our limited staff, we are only able to do a preliminary review of the project.

This review of your project indicates that it is in the following:

Karst invertebrates		Edwards Aquifer		Wetlands*	
☐	Zone 1	☐	Recharge zone	☐	None
☐	Zone 2	☐	Transition zone	☒	On or adjacent to site
☐	Zone 3	☒	Artesian zone		
☐	Zone 4	☐	Saline zone		
☒	Zone 5	☐	Contributing zone		
☐	No karst terrain				
☒	No Critical Habitat				

To assure that you are in compliance with federal law, you should evaluate the potential for your project to impact federally listed species and wetlands. We offer the following information to help you in that evaluation. A list of federally listed that occur in Bexar County is enclosed. The enclosed handouts and information are provided to assist project planners in determining if the project is likely to cause any impacts to resources the U.S. Fish and Wildlife Service (Service) is responsible for protecting. Projects that may affect federally listed species or their critical habitats under the Endangered Species Act of 1973, as amended, (Act) require formal consultation with the Service if the activity is authorized, funded, or carried out by a federal agency. It is the primary responsibility of the federal agency to determine whether its actions may affect a federally listed or proposed species.

Golden-cheeked warblers and black-capped vireos

Your proposed project has not been evaluated for potential impacts to the endangered golden-cheeked warbler (*Dendroica chrysoparia*) or black-capped vireo (*Vireo atricapilla*). For additional information on habitat requirements, please see the enclosed handouts "*Golden-cheeked Warbler*" and "*Black-capped Vireo*" produced by the Texas Parks and Wildlife Department (TPWD 1995)[1] or the Recovery Plan for each of these species[2 3]. These handouts describe the distribution, habitat requirements, and management guidelines for these two species. However, habitat in Bexar County differs slightly from other areas, in some cases having more Ashe junipers (*Juniperus ashei*) and live oaks (*Quercus fusiformis*) with fewer deciduous trees. Please consult with us further, if habitat for the warbler or vireo is likely to be affected either directly or indirectly.

Karst invertebrates

There are five karst zones in the Bexar County area based on geology, distribution of known caves, distribution of cave fauna, and primary factors that determine the presence, size, shape and extent of caves with respect to cave development[4]. The five zones reflect the likelihood of finding a karst feature that will provide habitat for endangered karst invertebrates as follows:

Zone 1 - Areas known to contain one or more of the nine invertebrates;
Zone 2 - Areas having a high probability of suitable habitat for the invertebrates;
Zone 3 - Areas that probably do not contain the invertebrates;
Zone 4 - Areas that require further research but are generally equivalent to zone 3, although they may include sections that could be classified as zone 2 or zone 5; and
Zone 5 - Areas that do not contain the invertebrates.

Karst refers to limestone formations containing caves, sinks, and fissures. Certain karst formations may have a high probability of one or more of nine endangered karst invertebrates occurring in that area. The entire ranges of these species occur in north and/or northwestern Bexar County. The species and their habitat may be threatened by a number of factors including destruction and/or deterioration of habitat by commercial, residential, and road construction; filling of caves; increase in impervious cover; potential contamination from such things as septic effluent, sewer leaks, runoff, pesticides; predation by and competition with non-native fire ants (*Solenopsis invicta*); and vandalism (Federal Register Vol. 65, No. 248, December 26, 2000).

Edwards Aquifer dependent species

For additional information on Edwards Aquifer dependent species, please refer to the enclosed handout, "*Edwards Aquifer Species*" (TPWD 1995[5]) or the Recovery Plan for these species[6]. Note: This handout is only enclosed for projects occurring in the recharge zone for the Aquifer.

---

[1] Campbell, Linda. Texas Parks and Wildlife Department, Endangered Resources Branch. 1995. Endangered and Threatened Animals of Texas: Their Life History and Management. Texas Parks and Wildlife Press.

[2] USFWS. 1991. Black-capped vireo Recovery Plan. Albuquerque, New Mexico.

[3] USFWS. 1992. Golden-cheeked warbler Recovery Plan. Albuquerque, New Mexico.

[4] Veni, G., and Associates. 1994. Geologic controls on cave development and the distribution of endemic cave fauna in the San Antonio, Texas region. Section 6 report prepared for the Texas Parks and Wildlife Department and the U.S. Fish and Wildlife Service.

[5] Campbell, Linda. Texas Parks and Wildlife Department, Endangered Resources Branch. 1995. Endangered and Threatened Animals of Texas: Their Life History and Management. Texas Parks and Wildlife Press.

For information on water quality and quantity measures designed to minimize or avoid impacts to the Edwards Aquifer in Bexar County, please contact the Texas Commission on Environmental Quality's Edwards Aquifer Protection Program, 14250 Judson Road, San Antonio, Texas, 78233-4480, phone 210-490-3096, fax 210-545-4329, e-mail eapp@tceq.state.tx.us, website http://www.tnrcc.state.tx.us/eapp/index.html.

Wetlands

Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at, or near, the surface and has hydrophytes, hydric or wetland soils, and are covered by shallow water at some time during the growing season of the year. Many wetlands are protected by law and require permits before they can be altered or destroyed. If your project will involve filling, dredging, or trenching of a wetland or riparian area it may require a Section 404 permit from the U.S. Army Corps of Engineers. For permitting requirements under Section 404 of the Clean Water Act, please contact the Fort Worth District, Permit Section, CESWF-EV-O, P.O. Box 17300, Fort Worth, Texas, 76102-0300, or call 817-978-2681.

State-listed species

The State of Texas protects certain species. Please contact the Texas Parks and Wildlife Department, Endangered Resources Branch, Fountain Park Plaza Building, Suite 100, 3000 South IH-35, Austin, Texas 78704, or call 512-912-7011 for information concerning fish, wildlife, and plants of state concern.

If after reviewing the enclosed information, you need additional advice or information, please contact us. If you determine your project is likely to impacts resources that are of concern to the Service, or which have legal protection and will require Service permits or consultation, please contact Jana Milliken at 512-490-0057, extension 243.

Sincerely,

Robert T. Pine
Supervisor

* We reviewed National Wetland Inventory (NWI) maps to make this assessment. However, NWI maps may not identify all wetland areas, thus an "on-site" visit, by the applicant or consultant, is also recommended and should follow consultation with the maps.

Enclosures: Bexar County species list (updated August 23, 2004)
TPWD Golden-cheeked warbler handout
TPWD Black-capped vireo handout

[6] USFWS. 1996. San Marcos and Comal Springs and Associates Aquatic Ecosystems (revised) Recovery Plan. Albuquerque, New Mexico.

Federally Listed as Threatened and Endangered Species of Bexar County

DISCLAIMER

This list is based on information available as of on August 23, 2004. This list is subject to change as new biological information is gathered and should not be used as the sole source for identifying species that may be impacted by a project.

Edwards Aquifer species: (Edwards Aquifer County) refers to those six counties underlain by the Edwards Aquifer: Kinney, Uvalde, Medina, Bexar, Hays, and Comal counties (Texas).

Comal Springs riffle beetle	(E)	*Heterelmis comalensis*
Comal Springs dryopid beetle	(E)	*Stygoparnus comalensis*
Fountain darter	(E w/CH)	*Etheostoma fonticola*
Peck's cave amphipod	(E)	*Stygobromus (=Stygonectes) pecki*
San Marcos gambusia	(E w/CH)	*Gambusia georgei*
Texas wild-rice	(E w/CH)	*Zizania texana*
Texas blind salamander	(E)	*Typhlomolge rathbuni*
San Marcos salamander	(T □w/CH)	*Eurycea nana*

Migratory Species Common to many or all Counties: Species listed specifically in a county have confirmed sightings. If a species is not listed they may occur as migrants in those counties.

Least tern	(E ~)	*Sterna antillarum*
Whooping crane	(E w/CH)	*Grus americana*
Bald eagle	(T)	*Haliaeetus leucocephalus*
Piping plover	(T w/CH)	*Charadrius melodus*

Bexar County (Edwards Aquifer County)

Black-capped vireo	(E)	*Vireo atricapilla*
Golden-cheeked warbler	(E)	*Dendroica chrysoparia*
Madla cave meshweaver	(E w/CH)	*Cicurina madla*
Robber Baron Cave meshweaver	(E w/CH)	*Cicurina baronia*
Braken Bat Cave meshweaver	(E w/CH)	*Cicurina venii*
Government Canyon Bat Cave meshweaver	(E)	*Cicurina vespera*
Government Canyon Bat Cave spider	(E)	*Neoleptoneta microps*
Cokendolpher cave harvestman	(E w/CH)	*Texella cokendolpheri*
Ground beetle (no common name)	(E w/CH)	*Rhadine exilis*
Ground beetle (no common name)	(E w/CH)	*Rhadine infernalis*
Helotes mold beetle	(E w/CH)	*Batrisodes venyivi*

Note: The Edwards Aquifer species listed above may be affected by activities within Bexar County, although they do not occur in Bexar County.

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Statewide or areawide migrants are not included by county, except where they breed or occur in concentrations. The whooping crane is an exception; an attempt is made to include all confirmed sightings on this list.

E = Species in danger of extinction throughout all or a significant portion of its range.

APPENDIX D

VISUAL SAMPLE PLAN DOCUMENTATION

R & H OIL ENERGY SITE
VSP PROJECTED NUMBER OF SOIL SAMPLES[1]

Parameter	Arsenic	Barium	Chromium	Lead	Benzene (nd = MDL)	Benzene (nd = 1/2 MDL)	Xylene (nd = MDL)	Xylene (nd = 1/2 MDL)	Benzo(a)pyrene (nd = MDL)	Benzo(a)pyrene (nd = 1/2 MDL)
Mean Concentration Existing Data Set[2] (mg/kg)	5.6	75.4	7.7	41.2	3.5	3.4	58.1	58.0	44.1	22.0
Standard Deviation Existing Data Set (mg/kg)	9.3	49.4	6.3	41.6	13.0	13.0	239.5	239.6	45.8	22.9
Sample Distribution Existing Data Set	Non-Normal	Normal	Non-Normal	Non-Normal	Non-Normal	Non-Normal	Non-Normal	Non-Normal	Non-Normal	Non-Normal
Desired False Positive Rate (Alpha) (%)	5	5	5	5	5	5	5	5	5	5
Desired False Negative Rate (Beta) (%)	5	5	5	5	5	5	5	5	5	5
Fixed Threshold (mg/kg)	16.7	7,800	210	400	0.66	0.66	210	210	0.062	0.062
Basis for Threshold	Background Concentration	RBV[3]	RBV	RBV	RBV	RBV	RBV	RBV	RBV	RBV
Gray Region Lower Boundary (mg/kg)	0.39	430	38.0	18.0	0.002	0.002	0.002	0.002	0.002	0.002
Basis for Lower Boundary	RBV	Background Concentration	Background Concentration	Background Concentration	PMDL[4]	PMDL	PMDL	PMDL	PMDL	PMDL
Delta between Threshold and Lower Boundary (mg/kg)	16.3	7,370	172	382	0.658	0.658	210	210	0.060	0.060
Projected No. of Samples	13	2	11	11	6,611	6,643	29	29	10,000	10,000

Notes:
1. Visual Site Plan (Version 4.0, July 2005) projected number of samples based on comparison of average to a fixed threshold.
2. Existing data set includes all surface and subsurface soil samples collected from the Site.
3. Risk-Based Value (RBV) based on EPA and TCEQ criteria for residential 30 acre source area.
4. Possible method detection limit (PMDL).
5. For evaluations with "nd = MDL" designation, non detectable values were set at the method detection limit for the purposes of calculating dataset characteristics.
6. For evaluations with "nd = 1/2 MDL" designation, non detectable values were set at one-half of the method detection limit for the purposes of calculating dataset characteristics.

APPENDIX D
VSP OUTPUT RESULTS

ARSENIC

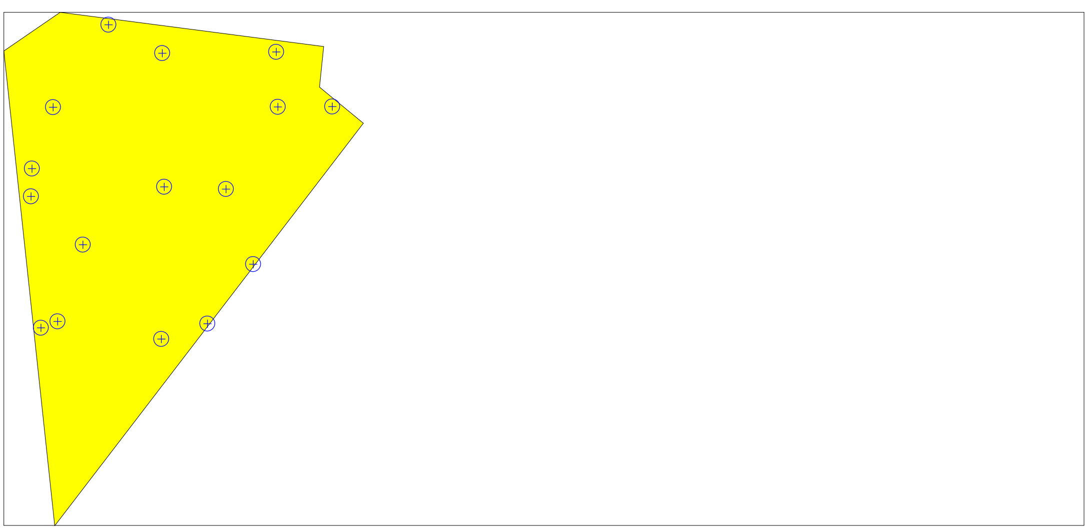
Random sampling locations for comparing a median with a fixed threshold (nonparametric - MARSSIM)

Summary
This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field and a table that lists sampling location coordinates are also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean or median to a fixed threshold
Type of Sampling Design	Nonparametric
Sample Placement (Location) in the Field	Simple random sampling
Working (Null) Hypothesis	The median(mean) value at the site exceeds the threshold
Formula for calculating number of sampling locations	Sign Test - MARSSIM version
Calculated total number of samples	16
Number of samples on map [a]	16
Number of selected sample areas [b]	1
Specified sampling area [c]	300838.47 ft^2
Total cost of sampling [d]	$9,000.00

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.
[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.
[d] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.



Area: Area 1

X Coord	Y Coord	Label	Value	Type	Historical
1787570.6176	10659860.2415	R-SO-4	1.8	Random	
1787495.8992	10660096.3712	R-SO-5	4.9	Random	
1787355.8167	10659996.7410	R-SO-7	3.3	Random	
1787689.5598	10660329.4643	R-SO-8	41.5	Random	
1787491.0147	10659833.6338	R-SO-9	1.9	Random	
1787283.7039	10659852.7834	R-SO-11	5.7	Random	
1787267.9870	10660128.1241	R-SO-12	1.5	Random	
1787266.2128	10660080.0474	R-SO-13/14 Average	7.9	Random	
1787692.0665	10660234.3680	R-SO-16	3	Random	
1787785.9567	10660234.9155	R-SO-17	2.6	Random	
1787399.8793	10660376.2365	R-SO-18	1.4	Random	
1787312.0597	10659864.0491	R-SO-19	1.1	Random	
1787602.7855	10660092.4260	R-SO-20	10.9	Random	
1787492.8075	10660327.1271	R-SO-21	2.5	Random	
1787304.5801	10660234.1454	R-SO-22	2	Random	
1787649.4483	10659962.7858	T-SO-1	4.1	Random	

Primary Sampling Objective
The primary purpose of sampling at this site is to compare a site median or mean value with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the median(mean) value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the median(mean) value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative one, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach
A nonparametric random sampling approach was used to determine the number of samples and to specify sampling locations. A nonparametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that typical parametric assumptions may not be true.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

Locating the sample points randomly provides data that are separated by many distances, whereas systematic samples are all equidistant apart. Therefore, random sampling provides more information about the spatial structure of the potential contamination than systematic sampling does. As with systematic sampling, random sampling also provides information regarding the mean value, but there is the possibility that areas of the site will not be represented with the same frequency as if uniform grid sampling were performed.

Number of Total Samples: Calculation Equation and Inputs
The equation used to calculate the number of samples is based on a Sign test (see PNNL 13450 for discussion). For this site, the null hypothesis is rejected in favor of the alternative one if the median(mean) is sufficiently smaller than the threshold. The number of samples to collect is calculated so that if the inputs to the equation are true, the calculated number of samples will cause the null hypothesis to be rejected.

The formula used to calculate the number of samples is:

$$n = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4(SignP - 0.5)^2}$$

where

$$SignP = \Phi\left(\frac{\Delta}{s_{total}}\right)$$

$\Phi(z)$	is the cumulative standard normal distribution on $(-\infty,z)$ (see PNNL-13450 for details),
n	is the number of samples,
S_{total}	is the estimated standard deviation of the measured values including analytical error,
Δ	is the width of the gray region,
α	is the acceptable probability of incorrectly concluding the site median(mean) is less than the threshold,
β	is the acceptable probability of incorrectly concluding the site median(mean) exceeds the threshold,
$Z_{1-\alpha}$	is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is $1-\alpha$,
$Z_{1-\beta}$	is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is $1-\beta$.

Note: MARSSIM suggests that the number of samples should be increased by at least 20% to account for missing or unusable data and uncertainty in the calculated value of n. VSP allows a user-supplied percent overage as discussed in MARSSIM (EPA 2000, p. 5-33).

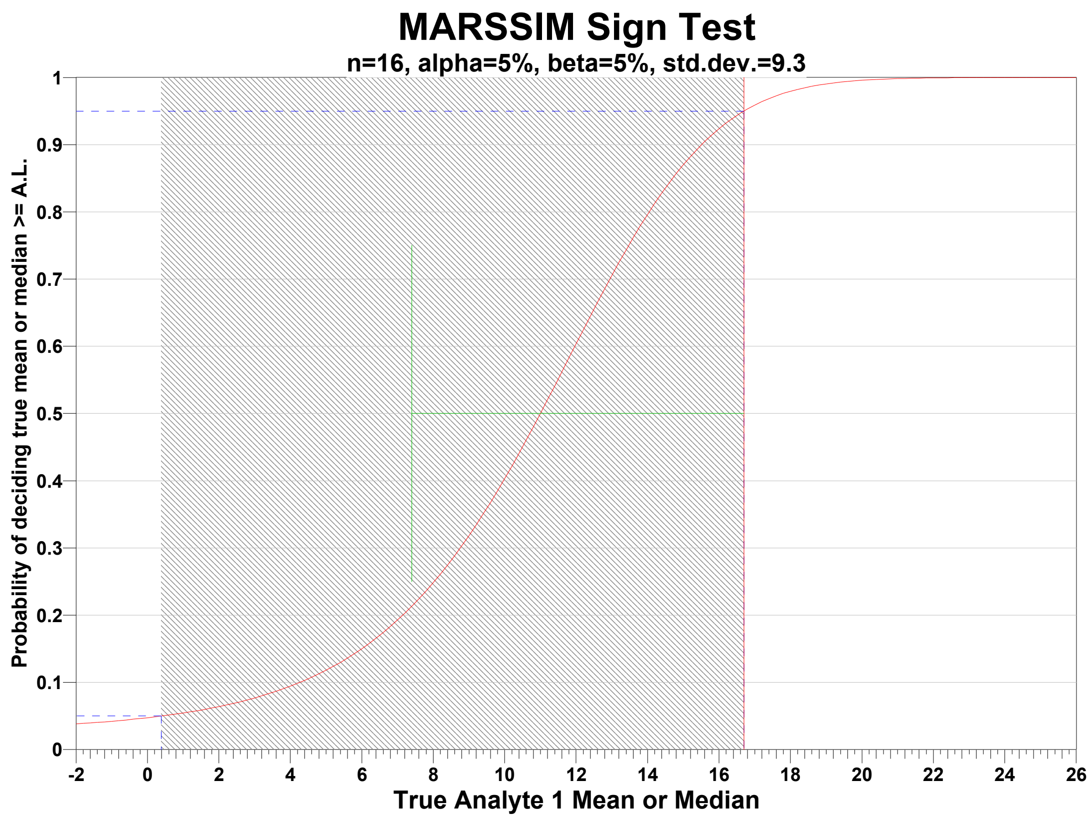
The values of these inputs that result in the calculated number of sampling locations are:

Analyte	**n**[a]	**Parameter**					
		S	Δ	α	β	$Z_{1-\alpha}$ [b]	$Z_{1-\beta}$ [c]
Analyte 1	16	9.3	16.31	0.05	0.05	1.64485	1.64485

[a] The final number of samples has been increased by the MARSSIM Overage of 20%.
[b] This value is automatically calculated by VSP based upon the user defined value of α.
[c] This value is automatically calculated by VSP based upon the user defined value of β.

The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true median(mean) values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the upper horizontal dashed blue line is positioned at $1-\alpha$ on the vertical axis; the lower horizontal dashed blue line is positioned at β on the vertical axis. The vertical green line is positioned at one standard deviation below the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at β and the upper bound of Δ at $1-\alpha$. If any of the inputs change, the number of samples that result in the correct curve changes.



Statistical Assumptions
The assumptions associated with the formulas for computing the number of samples are:
1. the computed sign test statistic is normally distributed,
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected randomly.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the sample locations were selected using a random process.

Sensitivity Analysis
The sensitivity of the calculation of number of samples was explored by varying the standard deviation, lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ > action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples							
AL=16.7		α=5		α=10		α=15	
		s=18.6	s=9.3	s=18.6	s=9.3	s=18.6	s=9.3
LBGR=90	β=5	2538	640	2009	507	1686	425
	β=10	2009	507	1541	389	1260	318
	β=15	1686	425	1260	318	1008	255
LBGR=80	β=5	640	166	507	131	425	111
	β=10	507	131	389	101	318	83
	β=15	425	111	318	83	255	66
LBGR=70	β=5	290	78	228	62	192	52
	β=10	228	62	176	48	144	39
	β=15	192	52	144	39	116	32

s = Standard Deviation
LBGR = Lower Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ > action level
α = Alpha (%), Probability of mistakenly concluding that μ < action level
AL = Action Level (Threshold)

Cost of Sampling
The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is $9,000.00, which averages out to a per sample cost of $562.50. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**16 Samples**
Field collection costs		$100.00	$1,600.00
Analytical costs	$400.00	$400.00	$6,400.00
Sum of Field & Analytical costs		**$500.00**	**$8,000.00**
Fixed planning and validation costs			$1,000.00
Total cost			**$9,000.00**

Data Analysis for Analyte 1
The following data points were entered by the user for analysis.

Analyte 1										
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	1.1	1.1	1.4	1.5	1.8	1.9	2	2.5	2.6	2.9
10	3	3.3	4.1	4.9	5.7	7.9	10.9	41.5		

SUMMARY STATISTICS for Analyte 1	
n	18
Min	1.1
Max	41.5
Range	40.4
Mean	5.5611
Median	2.75
Variance	86.994
StdDev	9.3271
Std Error	2.1984
Skewness	3.7529
Interquartile Range	3.375

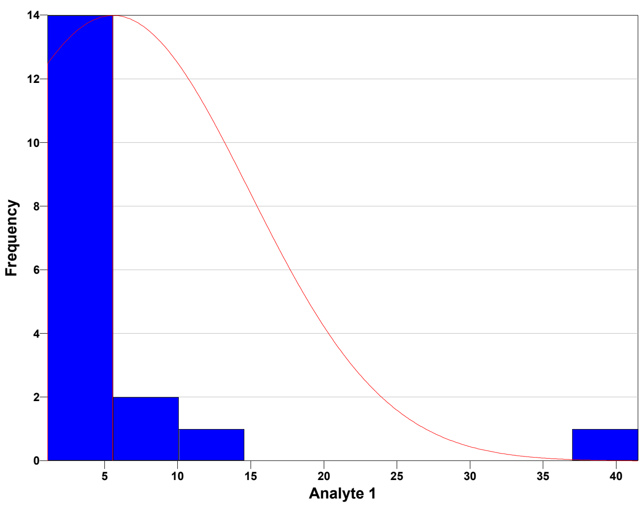
Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
1.1	1.1	1.1	1.725	2.75	5.1	13.96	41.5	41.5

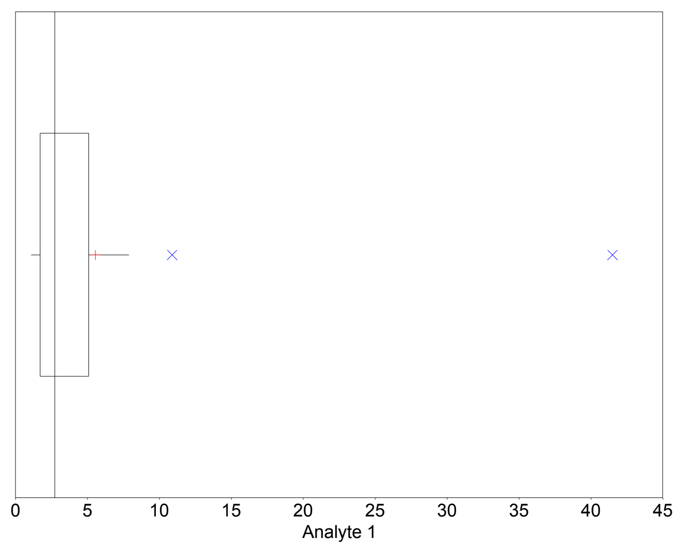
Data Plots
Three graphical displays of the data are shown below: the Histogram, the Box and Whiskers plot, and the Quantile-Quantile (Q-Q) plot.

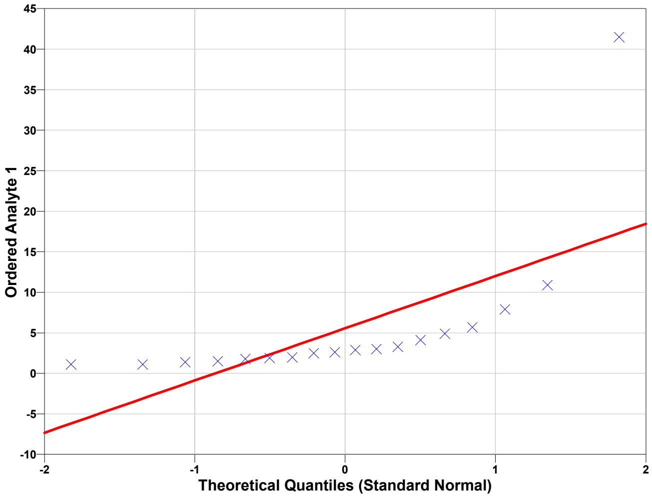
The Histogram is a plot of the fraction of the n observed data that fall within specified data “bins.” A histogram is generated by dividing the x axis (range of the observed data values) into "bins" and displaying the number of data in each bin as the height of a bar for the bin. The area of the bar is the fraction of the n data values that lie within the bin. The sum of the fractions for all bins equals one. A histogram is used to assess how the n data are distributed (spread) over their range of values. If the histogram is more or less symmetric and bell shaped, then the data may be normally distributed.

The Box and Whiskers plot is composed of a central box divided by a line, and with two lines extending out from the box, called the "whiskers". The line through the box is drawn at the median of the n data observed. The two ends of the box represent the 25th and 75th percentiles of the n data values, which are also called the lower and upper quartiles, respectively, of the data set. The sample mean (mean of the n data) is shown as a "+" sign. The upper whisker extends to the largest data value that is less than the upper quartile plus 1.5 times the interquartile range (upper quartile minus the lower quartile). The lower whisker extends to the smallest data value that is greater than the lower quartile minus 1.5 times the interquartile range. Extreme data values (greater or smaller than the ends of the whiskers) are plotted individually. A Box and Whiskers plot is used to assess the symmetry of the distribution of the data set. If the distribution is symmetrical, the box is divided into two equal halves by the median, the whiskers will be the same length, and the number of extreme data points will be distributed equally on either end of the plot.

The Q-Q plot graphs the quantiles of a set of n data against the quantiles of a specific distribution. We show here only the Q-Q plot for an assumed normal distribution. The pth quantile of a distribution of data is the data value, x_p, for which a fraction p of the distribution is less than x_p. If the data plotted on the normal distribution Q-Q plot closely follow a straight line, even at the ends of the line, then the data may be assumed to be normally distributed. If the data points deviate substantially from a linear line, then the data are not normally distributed.







For more information on these three plots consult Guidance for Data Quality Assessment, EPA QA/G-9, pgs 2.3-1 through 2.3-12. (http://www.epa.gov/quality/qa-docs.html).

Tests for Analyte 1
A goodness-of-fit test was performed to test whether the data set had been drawn from an underlying normal distribution. The Shapiro-Wilk (SW) test was used to test the null hypothesis that the data are normally distributed. The test was conducted at the 5% significance level, i.e., the probability the test incorrectly rejects the null hypothesis was set at 0.05.

NORMAL DISTRIBUTION TEST	
Shapiro-Wilk Test Statistic	0.4688
Shapiro-Wilk 5% Critical Value	0.897

The calculated SW test statistic is less than the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the data are normal, or in other words the data do not appear to follow a normal distribution at the 5% level of significance. The Q-Q plot displayed above should be used to further assess the normality of the data.

Upper Confidence Limit on the True Mean
Two methods were used to compute the upper confidence limit (UCL) on the mean. The first is a parametric method that assumes a normal distribution. The second is the Chebyshev method, which requires no distributional assumption.

UCLs ON THE MEAN	
95% Parametric UCL	9.3855
95% Non-Parametric (Chebyshev) UCL	15.144

Because the data do not appear to be normally distributed according to the goodness-of-fit test performed above, the non-parametric UCL (15.14) may be a more accurate upper confidence limit on the true mean.

MARSSIM Sign Test
The Sign test was performed in accordance with the guidance given in section 8.3.2 of MARSSIM. Each measurement was subtracted from the action level to obtain *n* differences $d_i = AL - X_i$. Any differences of zero were discarded from consideration and the sample size was reduced accordingly. The test statistic S+ was calculated by counting the positive differences. S+ was then compared with the critical value *k*, which was obtained from Table I.3 in Appendix I of MARSSIM.

If $S+ > k$, then the null hypothesis is rejected.

MARSSIM SIGN TEST		
Test Statistic S+	**95% Critical Value**	**Null Hypothesis**
17	12	Reject

The test rejected the null hypothesis that the mean value at the site exceeds the threshold, so conclude the site is clean.

APPENDIX D
VSP OUTPUT RESULTS

BARIUM

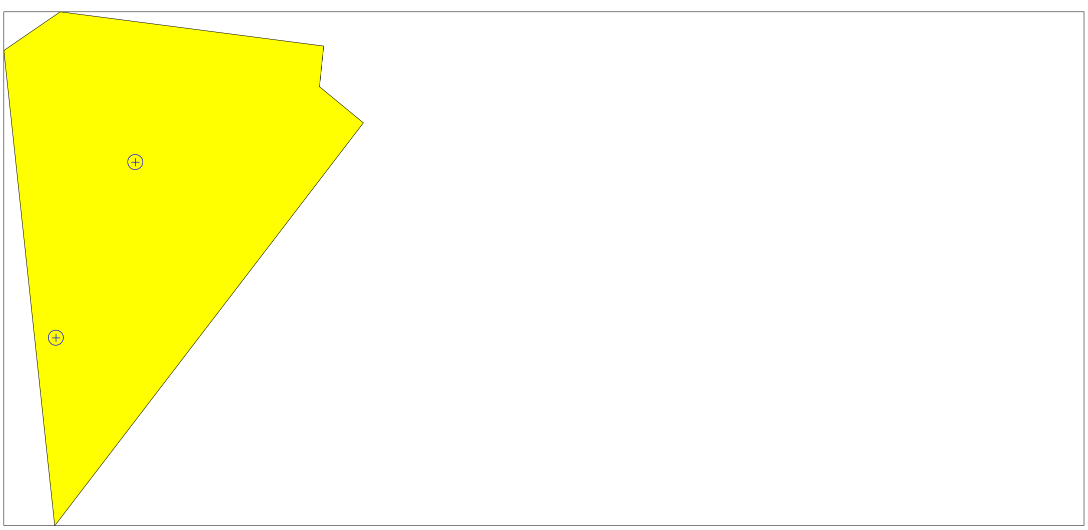
Random sampling locations for comparing a mean with a fixed threshold (parametric)

Summary
This report summarizes the sampling design, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design. A figure that shows sampling locations in the field and a table that lists sampling location coordinates are also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean to a fixed threshold
Type of Sampling Design	Parametric
Sample Placement (Location) in the Field	Simple random sampling
Working (Null) Hypothesis	The mean value at the site exceeds the threshold
Formula for calculating number of sampling locations	Student's t-test
Calculated total number of samples	2
Number of samples on map [a]	2
Number of selected sample areas [b]	1
Specified sampling area [c]	300838.47 ft^2
Total cost of sampling [d]	$2,000.00

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.
[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.
[d] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.



Area: Area 1

X Coord	Y Coord	Label	Value	Type	Historical
1787309.6956	10659835.5469			Random	
1787446.3530	10660138.5183			Random	

Primary Sampling Objective
The primary purpose of sampling at this site is to compare a mean value of a site with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the mean value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the mean value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative hypothesis, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach
A parametric random sampling approach was used to determine the number of samples and to specify sampling locations. A parametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that parametric assumptions are reasonable. These assumptions will be examined in post-sampling data analysis.

Both parametric and non-parametric approaches rely on assumptions about the population. However, non-parametric approaches typically require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than the number of samples required by non-parametric approaches.

Locating the sample points randomly provides data that are separated by many distances, whereas systematic samples are all equidistant apart. Therefore, random sampling provides more information about the spatial structure of the potential contamination than systematic sampling does. As with systematic sampling, random sampling also provides information regarding the mean value, but there is the possibility that areas of the site will not be represented with the same frequency as if uniform grid sampling were performed.

Number of Total Samples: Calculation Equation and Inputs
The equation used to calculate the number of samples is based on a Student's t-test. For this site, the null hypothesis is rejected in favor of the alternative hypothesis if the sample mean is sufficiently smaller than the threshold. The number of samples to collect is calculated so that 1) there will be a high probability ($1-\beta$) of rejecting the null hypothesis if the alternative hypothesis is true and 2) a low probability (α) of rejecting the null hypothesis if the null hypothesis is true.

The formula used to calculate the number of samples is:

$$n = \frac{S^2}{\Delta^2}\left(Z_{1-\alpha} + Z_{1-\beta}\right)^2 + 0.5Z_{1-\alpha}^2$$

where
- n is the number of samples,
- S is the estimated standard deviation of the measured values including analytical error,
- Δ is the width of the gray region,
- α is the acceptable probability of incorrectly concluding the site mean is less than the threshold,
- β is the acceptable probability of incorrectly concluding the site mean exceeds the threshold,
- $Z_{1-\alpha}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is $1-\alpha$,
- $Z_{1-\beta}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is $1-\beta$.

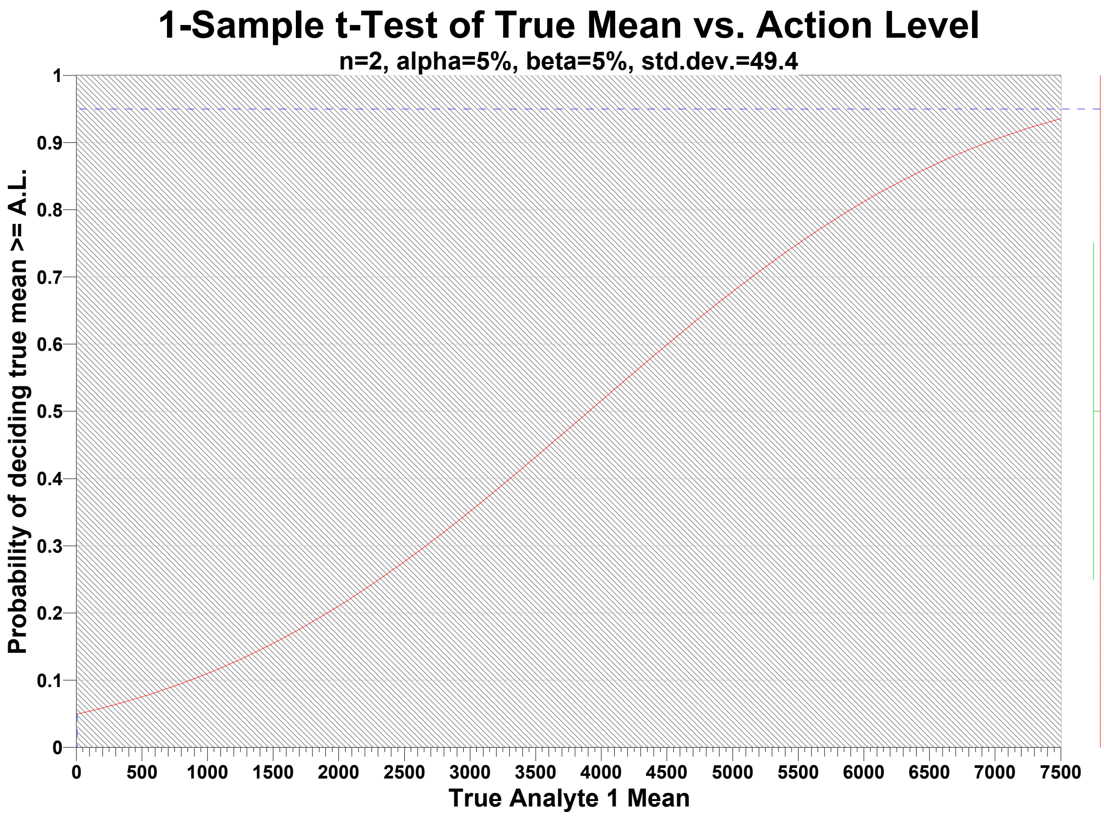
The values of these inputs that result in the calculated number of sampling locations are:

Analyte	n	Parameter					
		S	Δ	α	β	$Z_{1-\alpha}$ [a]	$Z_{1-\beta}$ [b]
Analyte 1	2	49.4	7791	0.05	0.05	1.64485	1.64485

[a] This value is automatically calculated by VSP based upon the user defined value of α.
[b] This value is automatically calculated by VSP based upon the user defined value of β.

The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true mean values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the upper horizontal dashed blue line is positioned at 1-α on the vertical axis; the lower horizontal dashed blue line is positioned at β on the vertical axis. The vertical green line is positioned at one standard deviation below the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at β and the upper bound of Δ at 1-α. If any of the inputs change, the number of samples that result in the correct curve changes.



Statistical Assumptions
The assumptions associated with the formulas for computing the number of samples are:

1. the sample mean is normally distributed (this happens if the data are roughly symmetric or the sample size is more than 30; for extremely skewed data sets, additional samples may be required for the sample mean to be normally distributed),
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected randomly.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the sample locations were selected using a random process.

Sensitivity Analysis
The sensitivity of the calculation of number of samples was explored by varying the standard deviation, lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ > action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples						
AL=7800	α=5		α=10		α=15	
	s=98.8	s=49.4	s=98.8	s=49.4	s=98.8	s=49.4

LBGR=90	**β=5**	2	2	1	1	1	1
	β=10	2	2	1	1	1	1
	β=15	2	2	1	1	1	1
LBGR=80	**β=5**	2	2	1	1	1	1
	β=10	2	2	1	1	1	1
	β=15	2	2	1	1	1	1
LBGR=70	**β=5**	2	2	1	1	1	1
	β=10	2	2	1	1	1	1
	β=15	2	2	1	1	1	1

s = Standard Deviation
LBGR = Lower Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ > action level
α = Alpha (%), Probability of mistakenly concluding that μ < action level
AL = Action Level (Threshold)

Cost of Sampling
The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is $2,000.00, which averages out to a per sample cost of $1,000.00. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**2 Samples**
Field collection costs		$100.00	$200.00
Analytical costs	$400.00	$400.00	$800.00
Sum of Field & Analytical costs		**$500.00**	**$1,000.00**
Fixed planning and validation costs			$1,000.00
Total cost			**$2,000.00**

Further Recommended Data Analysis Activities
Post data collection activities generally follow those outlined in EPA's Guidance for Data Quality Assessment (EPA, 2000). The data analysts will become familiar with the context of the problem and goals for data collection and assessment. The data will be verified and validated before being subjected to statistical or other analyses. Graphical and analytical tools will be used to verify to the extent possible the assumptions of any statistical analyses that are performed as well as to achieve a general understanding of the data. The data will be assessed to determine whether they are adequate in both quality and quantity to support the primary objective of sampling.

Because the primary objective for sampling for this site is to compare the site mean value with a threshold value, the data will be assessed in this context. Assuming the data are adequate, at least one statistical test will be done to perform a comparison between the data and the threshold of interest. Results of the exploratory and quantitative assessments of the data will be reported, along with conclusions that may be supported by them.

APPENDIX D
VSP OUTPUT RESULTS

CHROMIUM

Random sampling locations for comparing a median with a fixed threshold (nonparametric - MARSSIM)

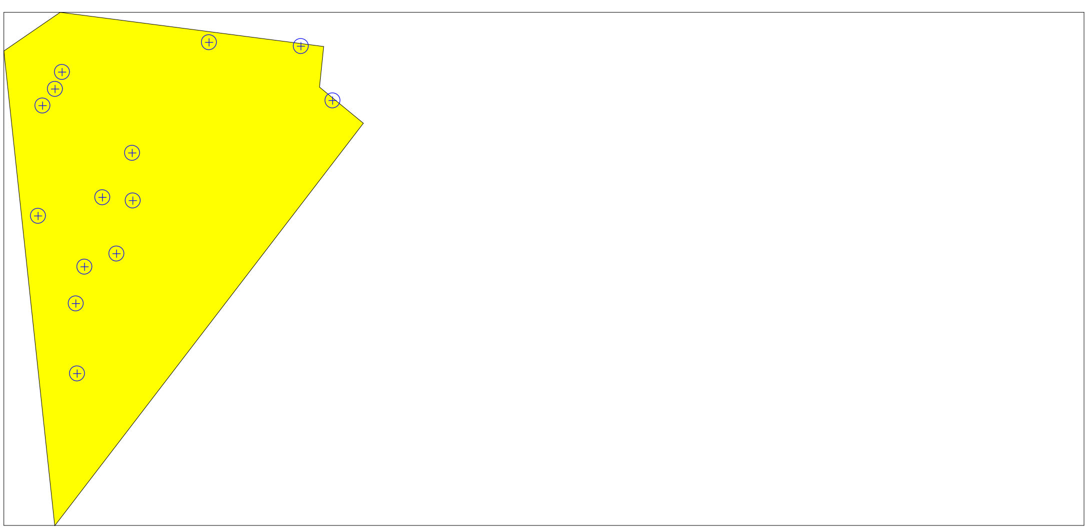
Summary

This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field and a table that lists sampling location coordinates are also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean or median to a fixed threshold
Type of Sampling Design	Nonparametric
Sample Placement (Location) in the Field	Simple random sampling
Working (Null) Hypothesis	The median(mean) value at the site exceeds the threshold
Formula for calculating number of sampling locations	Sign Test - MARSSIM version
Calculated total number of samples	14
Number of samples on map [a]	14
Number of selected sample areas [b]	1
Specified sampling area [c]	300838.47 ft^2
Total cost of sampling [d]	$8,000.00

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.
[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.
[d] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.



Area: Area 1

X Coord	Y Coord	Label	Value	Type	Historical
1787286.2674	10660236.7386	R-SO-4	3.4	Random	
1787786.6587	10660245.6149	R-SO-5	2.7	Random	
1787278.3584	10660046.4285	R-SO-6	2.1	Random	
1787573.2223	10660345.9159	R-SO-7	8.9	Random	
1787389.4182	10660078.3188	R-SO-8	3.7	Random	
1787413.5974	10659981.0224	R-SO-9	5.3	Random	
1787731.8348	10660339.2893	R-SO-11	23.8	Random	
1787441.1478	10660155.2343	R-SO-12	3.7	Random	
1787320.1633	10660294.8305	R-SO-13/14	21.1	Random	
1787343.7023	10659895.2036	R-SO-16	10.9	Random	
1787307.7197	10660265.1490	R-SO-17	11.1	Random	
1787442.0305	10660072.5975	R-SO-18	1	Random	
1787346.1341	10659773.7462	R-SO-19	4.1	Random	
1787358.8426	10659958.3733	R-SO-20	6.7	Random	

Primary Sampling Objective
The primary purpose of sampling at this site is to compare a site median or mean value with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the median(mean) value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the median(mean) value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative one, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach
A nonparametric random sampling approach was used to determine the number of samples and to specify sampling locations. A nonparametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that typical parametric assumptions may not be true.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

Locating the sample points randomly provides data that are separated by many distances, whereas systematic samples are all equidistant apart. Therefore, random sampling provides more information about the spatial structure of the potential contamination than systematic sampling does. As with systematic sampling, random sampling also provides information regarding the mean value, but there is the possibility that areas of the site will not be represented with the same frequency as if uniform grid sampling were performed.

Number of Total Samples: Calculation Equation and Inputs
The equation used to calculate the number of samples is based on a Sign test (see PNNL 13450 for discussion). For this site, the null hypothesis is rejected in favor of the alternative one if the median(mean) is sufficiently smaller than the threshold. The number of samples to collect is calculated so that if the inputs to the equation are true, the calculated number of samples will cause the null hypothesis to be rejected.

The formula used to calculate the number of samples is:

$$n = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4(SignP - 0.5)^2}$$

where

$$SignP = \Phi\left(\frac{\Delta}{s_{total}}\right)$$

$\Phi(z)$ is the cumulative standard normal distribution on $(-\infty,z)$ (see PNNL-13450 for details),
n is the number of samples,
S_{total} is the estimated standard deviation of the measured values including analytical error,
Δ is the width of the gray region,
α is the acceptable probability of incorrectly concluding the site median(mean) is less than the threshold,
β is the acceptable probability of incorrectly concluding the site median(mean) exceeds the threshold,
$Z_{1-\alpha}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is $1-\alpha$,
$Z_{1-\beta}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is $1-\beta$.

Note: MARSSIM suggests that the number of samples should be increased by at least 20% to account for missing or unusable data and uncertainty in the calculated value of n. VSP allows a user-supplied percent overage as discussed in MARSSIM (EPA 2000, p. 5-33).

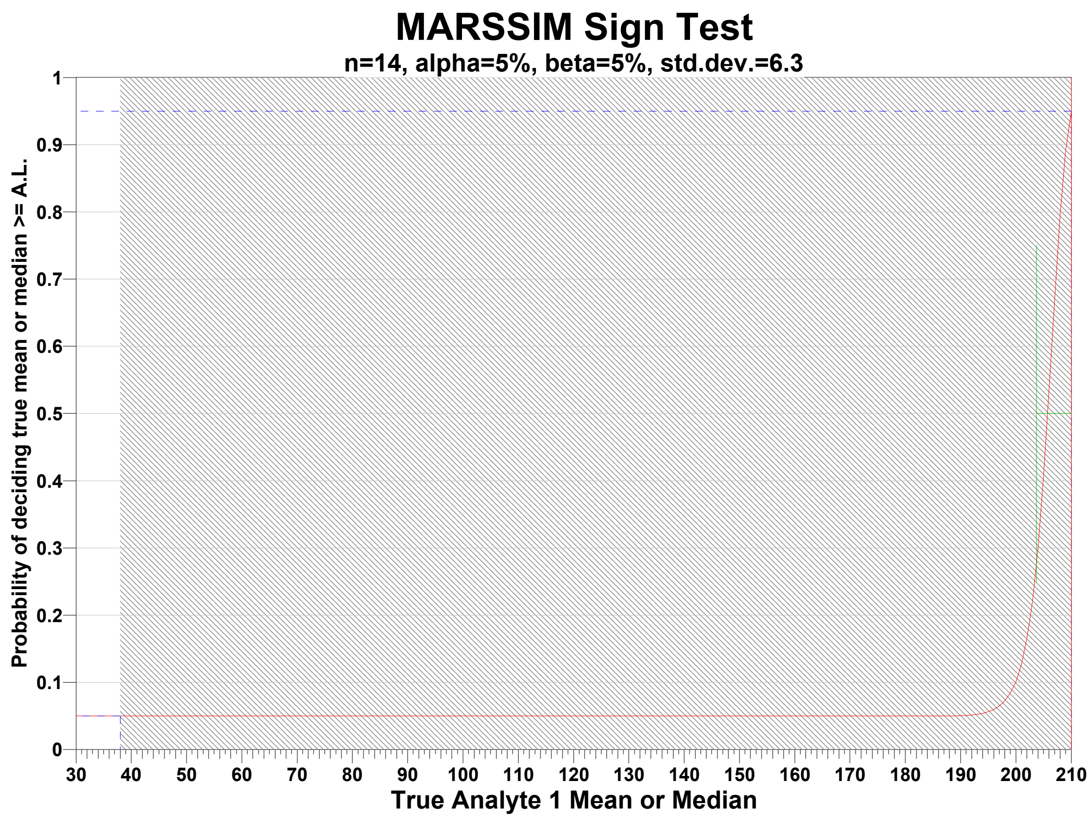
The values of these inputs that result in the calculated number of sampling locations are:

Analyte	**n**[a]	**Parameter**					
		S	**Δ**	**α**	**β**	$Z_{1-\alpha}$ [b]	$Z_{1-\beta}$ [c]
Analyte 1	14	6.3	172	0.05	0.05	1.64485	1.64485

[a] The final number of samples has been increased by the MARSSIM Overage of 20%.
[b] This value is automatically calculated by VSP based upon the user defined value of α.
[c] This value is automatically calculated by VSP based upon the user defined value of β.

The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true median(mean) values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the upper horizontal dashed blue line is positioned at $1-\alpha$ on the vertical axis; the lower horizontal dashed blue line is positioned at β on the vertical axis. The vertical green line is positioned at one standard deviation below the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at β and the upper bound of Δ at $1-\alpha$. If any of the inputs change, the number of samples that result in the correct curve changes.



Statistical Assumptions
The assumptions associated with the formulas for computing the number of samples are:
1. the computed sign test statistic is normally distributed,
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected randomly.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the sample locations were selected using a random process.

Sensitivity Analysis
The sensitivity of the calculation of number of samples was explored by varying the standard deviation, lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ > action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples							
AL=210		α=5		α=10		α=15	
		s=12.6	s=6.3	s=12.6	s=6.3	s=12.6	s=6.3
LBGR=90	β=5	17	14	14	11	11	10
	β=10	14	11	11	9	9	8
	β=15	11	10	9	8	8	6
LBGR=80	β=5	14	14	11	11	10	10
	β=10	11	11	9	9	8	8
	β=15	10	10	8	8	6	6
LBGR=70	β=5	14	14	11	11	10	10
	β=10	11	11	9	9	8	8
	β=15	10	10	8	8	6	6

s = Standard Deviation
LBGR = Lower Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ > action level
α = Alpha (%), Probability of mistakenly concluding that μ < action level
AL = Action Level (Threshold)

Cost of Sampling
The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is $8,000.00, which averages out to a per sample cost of $571.43. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**14 Samples**
Field collection costs		$100.00	$1,400.00
Analytical costs	$400.00	$400.00	$5,600.00
Sum of Field & Analytical costs		**$500.00**	**$7,000.00**
Fixed planning and validation costs			$1,000.00
Total cost			**$8,000.00**

Data Analysis for Analyte 1
The following data points were entered by the user for analysis.

Analyte 1										
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	1	2.1	2.7	2.7	3.4	3.7	3.7	4.1	5.3	6.7
10	7.5	8.7	8.9	10.9	10.9	11.1	21.1	23.8		

SUMMARY STATISTICS for Analyte 1	
n	18
Min	1
Max	23.8
Range	22.8
Mean	7.6833
Median	6
Variance	39.397
StdDev	6.2767
Std Error	1.4794
Skewness	1.5321
Interquartile Range	7.675

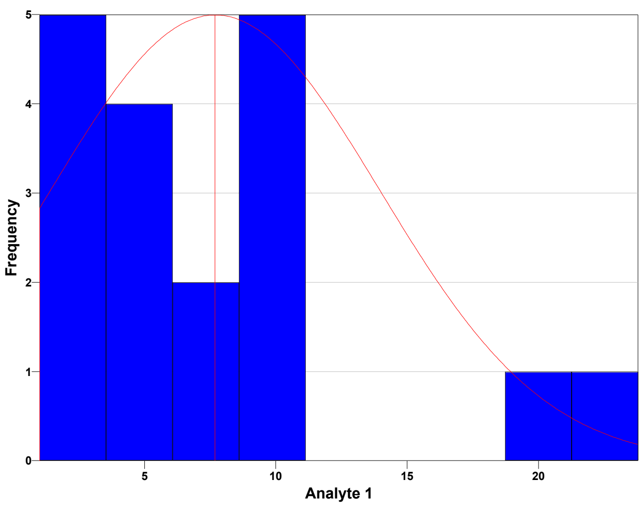
Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
1	1	1.99	3.225	6	10.9	21.37	23.8	23.8

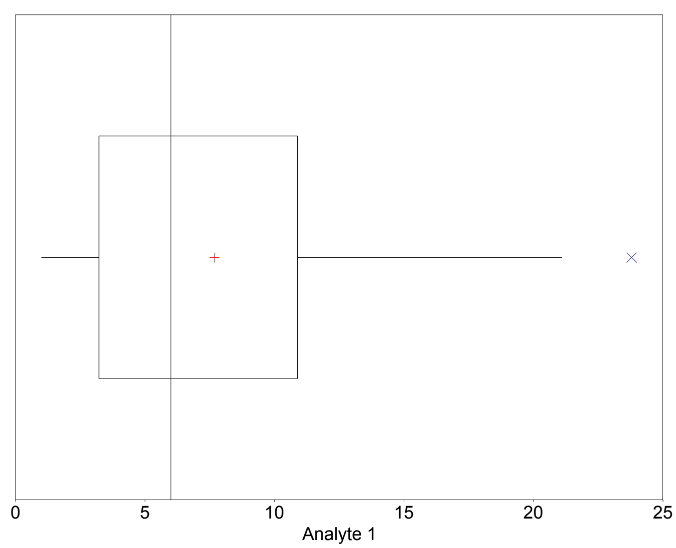
Data Plots
Three graphical displays of the data are shown below: the Histogram, the Box and Whiskers plot, and the Quantile-Quantile (Q-Q) plot.

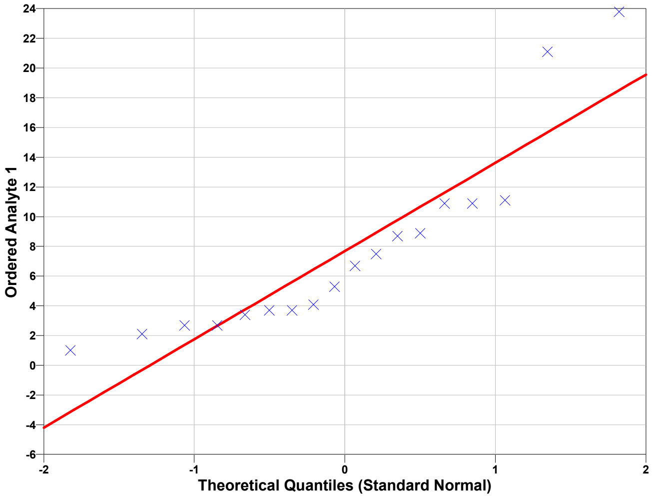
The Histogram is a plot of the fraction of the n observed data that fall within specified data “bins.” A histogram is generated by dividing the x axis (range of the observed data values) into "bins" and displaying the number of data in each bin as the height of a bar for the bin. The area of the bar is the fraction of the n data values that lie within the bin. The sum of the fractions for all bins equals one. A histogram is used to assess how the n data are distributed (spread) over their range of values. If the histogram is more or less symmetric and bell shaped, then the data may be normally distributed.

The Box and Whiskers plot is composed of a central box divided by a line, and with two lines extending out from the box, called the "whiskers". The line through the box is drawn at the median of the n data observed. The two ends of the box represent the 25^{th} and 75^{th} percentiles of the n data values, which are also called the lower and upper quartiles, respectively, of the data set. The sample mean (mean of the n data) is shown as a "+" sign. The upper whisker extends to the largest data value that is less than the upper quartile plus 1.5 times the interquartile range (upper quartile minus the lower quartile). The lower whisker extends to the smallest data value that is greater than the lower quartile minus 1.5 times the interquartile range. Extreme data values (greater or smaller than the ends of the whiskers) are plotted individually. A Box and Whiskers plot is used to assess the symmetry of the distribution of the data set. If the distribution is symmetrical, the box is divided into two equal halves by the median, the whiskers will be the same length, and the number of extreme data points will be distributed equally on either end of the plot.

The Q-Q plot graphs the quantiles of a set of n data against the quantiles of a specific distribution. We show here only the Q-Q plot for an assumed normal distribution. The p^{th} quantile of a distribution of data is the data value, x_p, for which a fraction p of the distribution is less than x_p. If the data plotted on the normal distribution Q-Q plot closely follow a straight line, even at the ends of the line, then the data may be assumed to be normally distributed. If the data points deviate substantially from a linear line, then the data are not normally distributed.







For more information on these three plots consult Guidance for Data Quality Assessment, EPA QA/G-9, pgs 2.3-1 through 2.3-12. (http://www.epa.gov/quality/qa-docs.html).

Tests for Analyte 1
A goodness-of-fit test was performed to test whether the data set had been drawn from an underlying normal distribution. The Shapiro-Wilk (SW) test was used to test the null hypothesis that the data are normally distributed. The test was conducted at the 5% significance level, i.e., the probability the test incorrectly rejects the null hypothesis was set at 0.05.

NORMAL DISTRIBUTION TEST	
Shapiro-Wilk Test Statistic	0.8281
Shapiro-Wilk 5% Critical Value	0.897

The calculated SW test statistic is less than the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the data are normal, or in other words the data do not appear to follow a normal distribution at the 5% level of significance. The Q-Q plot displayed above should be used to further assess the normality of the data.

Upper Confidence Limit on the True Mean
Two methods were used to compute the upper confidence limit (UCL) on the mean. The first is a parametric method that assumes a normal distribution. The second is the Chebyshev method, which requires no distributional assumption.

UCLs ON THE MEAN	
95% Parametric UCL	10.257
95% Non-Parametric (Chebyshev) UCL	14.132

Because the data do not appear to be normally distributed according to the goodness-of-fit test performed above, the non-parametric UCL (14.13) may be a more accurate upper confidence limit on the true mean.

MARSSIM Sign Test
The Sign test was performed in accordance with the guidance given in section 8.3.2 of MARSSIM. Each measurement was subtracted from the action level to obtain *n* differences $d_i = AL - X_i$. Any differences of zero were discarded from consideration and the sample size was reduced accordingly. The test statistic S+ was calculated by counting the positive differences. S+ was then compared with the critical value *k*, which was obtained from Table I.3 in Appendix I of MARSSIM.

If $S+ > k$, then the null hypothesis is rejected.

MARSSIM SIGN TEST		
Test Statistic S+	**95% Critical Value**	**Null Hypothesis**
18	12	Reject

The test rejected the null hypothesis that the mean value at the site exceeds the threshold, so conclude the site is clean.

APPENDIX D
VSP OUTPUT RESULTS

LEAD

Random sampling locations for comparing a median with a fixed threshold (nonparametric - MARSSIM)

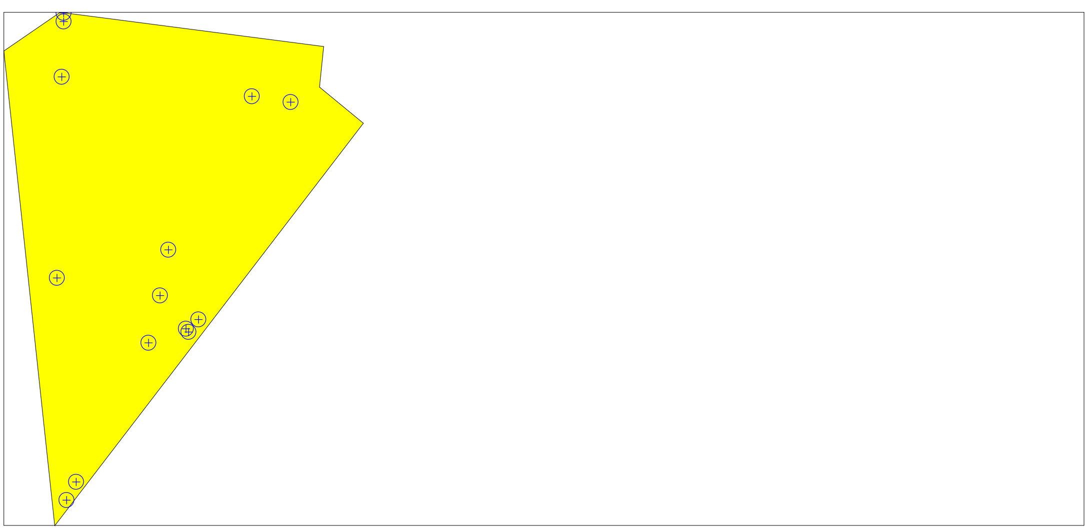
Summary

This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field and a table that lists sampling location coordinates are also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean or median to a fixed threshold
Type of Sampling Design	Nonparametric
Sample Placement (Location) in the Field	Simple random sampling
Working (Null) Hypothesis	The median(mean) value at the site exceeds the threshold
Formula for calculating number of sampling locations	Sign Test - MARSSIM version
Calculated total number of samples	14
Number of samples on map [a]	14
Number of selected sample areas [b]	1
Specified sampling area [c]	300838.47 ft^2
Total cost of sampling [d]	$8,000.00

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.
[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.
[d] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.



Area: Area 1

X Coord	Y Coord	Label	Value	Type	Historical
1787533.8439	10659851.4842	R-SO-4	9.5	Random	
1787503.0574	10659987.7756	R-SO-5	13.7	Random	
1787319.4984	10660286.1147	R-SO-6	7.1	Random	
1787327.7752	10659555.2388	R-SO-7	35.7	Random	
1787344.5387	10659586.5946	R-SO-8	51.7	Random	
1787555.1111	10659867.2843	R-SO-9	48.1	Random	
1787713.9241	10660242.7170	R-SO-11	56.7	Random	
1787323.0105	10660396.9742	R-SO-12	25.3	Random	
1787468.7880	10659826.9897	R-SO-13/14	179.5	Random	
1787322.9360	10660381.7858	R-SO-16	77.3	Random	
1787537.7942	10659845.9044	R-SO-17	28.2	Random	
1787647.3928	10660252.6272	R-SO-18	6	Random	
1787488.8026	10659908.7625	R-SO-19	21.5	Random	
1787311.2875	10659938.9656	R-SO-20	97.2	Random	

Primary Sampling Objective
The primary purpose of sampling at this site is to compare a site median or mean value with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the median(mean) value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the median(mean) value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative one, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach
A nonparametric random sampling approach was used to determine the number of samples and to specify sampling locations. A nonparametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that typical parametric assumptions may not be true.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

Locating the sample points randomly provides data that are separated by many distances, whereas systematic samples are all equidistant apart. Therefore, random sampling provides more information about the spatial structure of the potential contamination than systematic sampling does. As with systematic sampling, random sampling also provides information regarding the mean value, but there is the possibility that areas of the site will not be represented with the same frequency as if uniform grid sampling were performed.

Number of Total Samples: Calculation Equation and Inputs
The equation used to calculate the number of samples is based on a Sign test (see PNNL 13450 for discussion). For this site, the null hypothesis is rejected in favor of the alternative one if the median(mean) is sufficiently smaller than the threshold. The number of samples to collect is calculated so that if the inputs to the equation are true, the calculated number of samples will cause the null hypothesis to be rejected.

The formula used to calculate the number of samples is:

$$n = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4(SignP - 0.5)^2}$$

where

$$SignP = \Phi\left(\frac{\Delta}{s_{total}}\right)$$

$\Phi(z)$ is the cumulative standard normal distribution on $(-\infty,z)$ (see PNNL-13450 for details),
n is the number of samples,
S_{total} is the estimated standard deviation of the measured values including analytical error,
Δ is the width of the gray region,
α is the acceptable probability of incorrectly concluding the site median(mean) is less than the threshold,
β is the acceptable probability of incorrectly concluding the site median(mean) exceeds the threshold,
$Z_{1-\alpha}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is $1-\alpha$,
$Z_{1-\beta}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is $1-\beta$.

Note: MARSSIM suggests that the number of samples should be increased by at least 20% to account for missing or unusable data and uncertainty in the calculated value of n. VSP allows a user-supplied percent overage as discussed in MARSSIM (EPA 2000, p. 5-33).

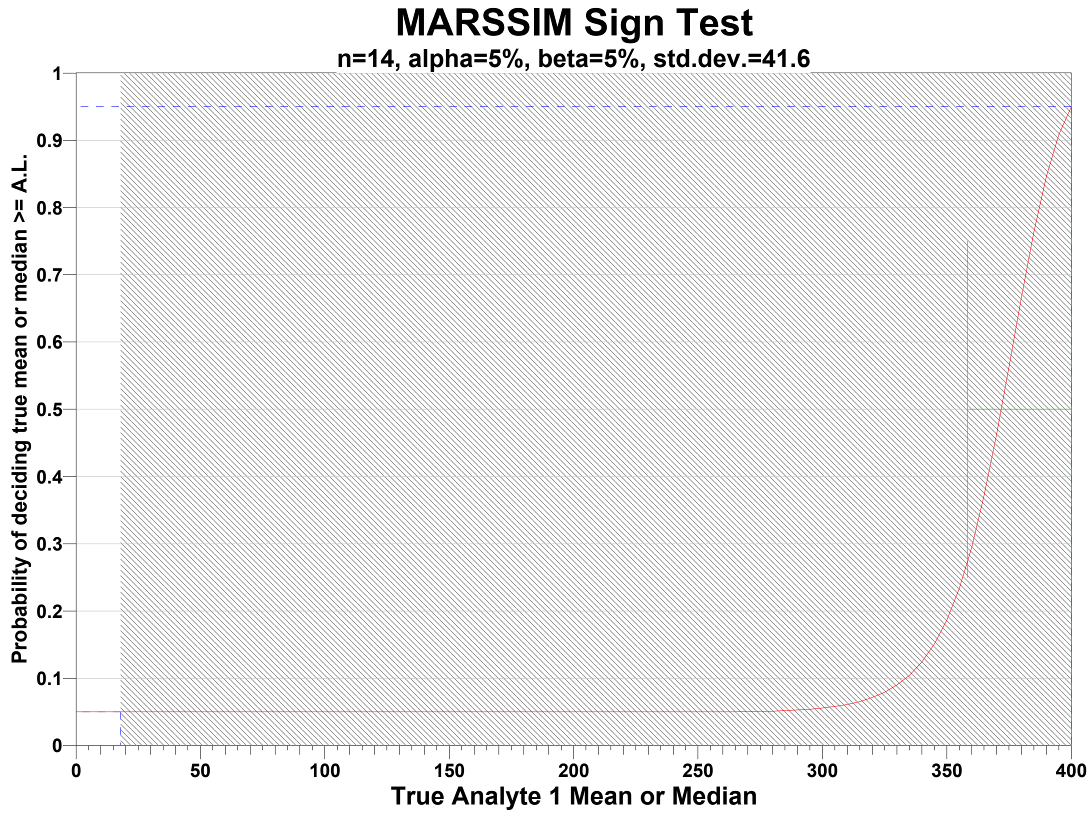
The values of these inputs that result in the calculated number of sampling locations are:

Analyte	**n**[a]	**Parameter**					
		S	**Δ**	**α**	**β**	$Z_{1-\alpha}$ [b]	$Z_{1-\beta}$ [c]
Analyte 1	14	41.6	382	0.05	0.05	1.64485	1.64485

[a] The final number of samples has been increased by the MARSSIM Overage of 20%.
[b] This value is automatically calculated by VSP based upon the user defined value of α.
[c] This value is automatically calculated by VSP based upon the user defined value of β.

The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true median(mean) values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the upper horizontal dashed blue line is positioned at $1-\alpha$ on the vertical axis; the lower horizontal dashed blue line is positioned at β on the vertical axis. The vertical green line is positioned at one standard deviation below the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at β and the upper bound of Δ at $1-\alpha$. If any of the inputs change, the number of samples that result in the correct curve changes.



Statistical Assumptions
The assumptions associated with the formulas for computing the number of samples are:
1. the computed sign test statistic is normally distributed,
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected randomly.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the sample locations were selected using a random process.

Sensitivity Analysis
The sensitivity of the calculation of number of samples was explored by varying the standard deviation, lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ > action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples							
AL=400		α=5		α=10		α=15	
		s=83.2	s=41.6	s=83.2	s=41.6	s=83.2	s=41.6
LBGR=90	β=5	96	30	76	24	64	21
	β=10	76	24	59	18	48	16
	β=15	64	21	48	16	39	12
LBGR=80	β=5	30	16	24	12	21	11
	β=10	24	12	18	10	16	9
	β=15	21	11	16	9	12	6
LBGR=70	β=5	18	14	15	11	12	10
	β=10	15	11	12	9	10	8
	β=15	12	10	10	8	8	6

s = Standard Deviation
LBGR = Lower Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ > action level
α = Alpha (%), Probability of mistakenly concluding that μ < action level
AL = Action Level (Threshold)

Cost of Sampling
The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is $8,000.00, which averages out to a per sample cost of $571.43. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**14 Samples**
Field collection costs		$100.00	$1,400.00
Analytical costs	$400.00	$400.00	$5,600.00
Sum of Field & Analytical costs		**$500.00**	**$7,000.00**
Fixed planning and validation costs			$1,000.00
Total cost			**$8,000.00**

Data Analysis for Analyte 1
The following data points were entered by the user for analysis.

Analyte 1										
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	6	7.1	8.4	9.5	13.7	14.4	21.5	22	25.3	28.2
10	35.7	36.6	43.5	48.1	51.7	56.7	77.3	97.2	179.5	

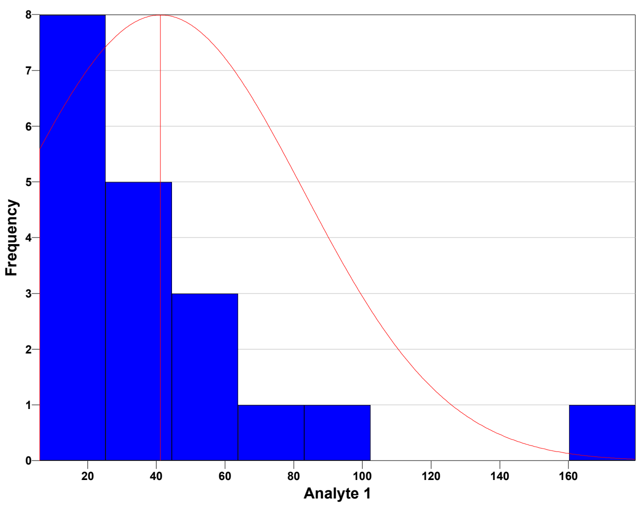
SUMMARY STATISTICS for Analyte 1								
n	19							
Min	6							
Max	179.5							
Range	173.5							
Mean	41.179							
Median	28.2							
Variance	1730.9							
StdDev	41.604							
Std Error	9.5447							
Skewness	2.2965							
Interquartile Range	38							
Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
6	6	7.1	13.7	28.2	51.7	97.2	179.5	179.5

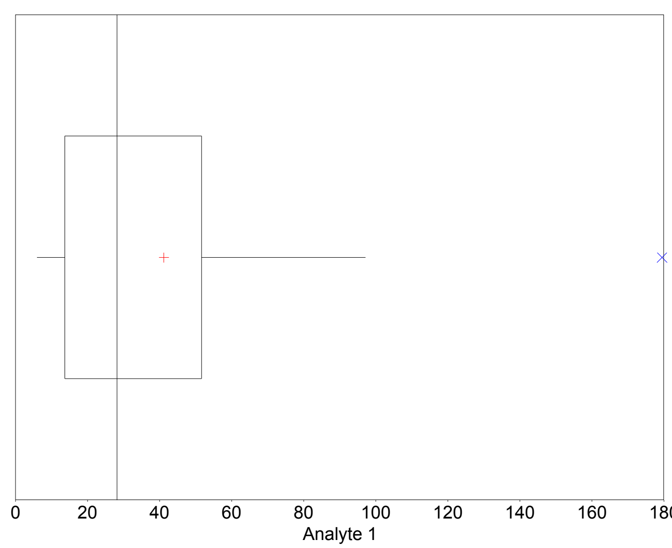
Data Plots
Three graphical displays of the data are shown below: the Histogram, the Box and Whiskers plot, and the Quantile-Quantile (Q-Q) plot.

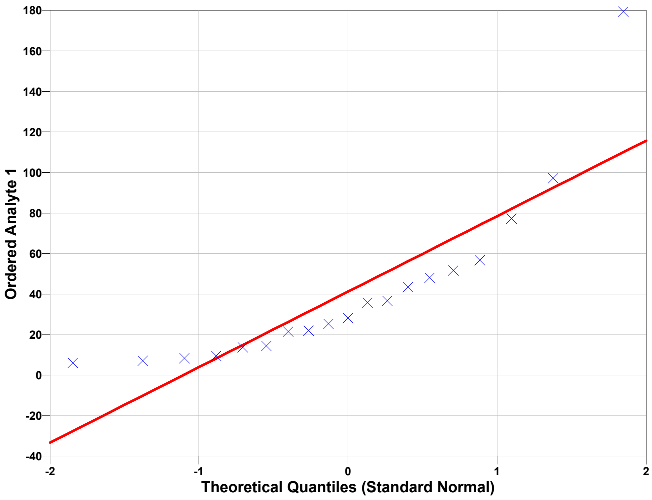
The Histogram is a plot of the fraction of the n observed data that fall within specified data “bins.” A histogram is generated by dividing the x axis (range of the observed data values) into "bins" and displaying the number of data in each bin as the height of a bar for the bin. The area of the bar is the fraction of the n data values that lie within the bin. The sum of the fractions for all bins equals one. A histogram is used to assess how the n data are distributed (spread) over their range of values. If the histogram is more or less symmetric and bell shaped, then the data may be normally distributed.

The Box and Whiskers plot is composed of a central box divided by a line, and with two lines extending out from the box, called the "whiskers". The line through the box is drawn at the median of the n data observed. The two ends of the box represent the 25th and 75th percentiles of the n data values, which are also called the lower and upper quartiles, respectively, of the data set. The sample mean (mean of the n data) is shown as a "+" sign. The upper whisker extends to the largest data value that is less than the upper quartile plus 1.5 times the interquartile range (upper quartile minus the lower quartile). The lower whisker extends to the smallest data value that is greater than the lower quartile minus 1.5 times the interquartile range. Extreme data values (greater or smaller than the ends of the whiskers) are plotted individually. A Box and Whiskers plot is used to assess the symmetry of the distribution of the data set. If the distribution is symmetrical, the box is divided into two equal halves by the median, the whiskers will be the same length, and the number of extreme data points will be distributed equally on either end of the plot.

The Q-Q plot graphs the quantiles of a set of n data against the quantiles of a specific distribution. We show here only the Q-Q plot for an assumed normal distribution. The pth quantile of a distribution of data is the data value, x_p, for which a fraction p of the distribution is less than x_p. If the data plotted on the normal distribution Q-Q plot closely follow a straight line, even at the ends of the line, then the data may be assumed to be normally distributed. If the data points deviate substantially from a linear line, then the data are not normally distributed.







For more information on these three plots consult Guidance for Data Quality Assessment, EPA QA/G-9, pgs 2.3-1 through 2.3-12. (http://www.epa.gov/quality/qa-docs.html).

Tests for Analyte 1
A goodness-of-fit test was performed to test whether the data set had been drawn from an underlying normal distribution. The Shapiro-Wilk (SW) test was used to test the null hypothesis that the data are normally distributed. The test was conducted at the 5% significance level, i.e., the probability the test incorrectly rejects the null hypothesis was set at 0.05.

NORMAL DISTRIBUTION TEST	
Shapiro-Wilk Test Statistic	0.758
Shapiro-Wilk 5% Critical Value	0.901

The calculated SW test statistic is less than the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the data are normal, or in other words the data do not appear to follow a normal distribution at the 5% level of significance. The Q-Q plot displayed above should be used to further assess the normality of the data.

Upper Confidence Limit on the True Mean
Two methods were used to compute the upper confidence limit (UCL) on the mean. The first is a parametric method that assumes a normal distribution. The second is the Chebyshev method, which requires no distributional assumption.

UCLs ON THE MEAN	
95% Parametric UCL	57.73
95% Non-Parametric (Chebyshev) UCL	82.783

Because the data do not appear to be normally distributed according to the goodness-of-fit test performed above, the non-parametric UCL (82.78) may be a more accurate upper confidence limit on the true mean.

MARSSIM Sign Test
The Sign test was performed in accordance with the guidance given in section 8.3.2 of MARSSIM. Each measurement was subtracted from the action level to obtain n differences $d_i = AL - X_i$. Any differences of zero were discarded from consideration and the sample size was reduced accordingly. The test statistic S+ was calculated by counting the positive differences. S+ was then compared with the critical value k, which was obtained from Table I.3 in Appendix I of MARSSIM.

If $S+ > k$, then the null hypothesis is rejected.

MARSSIM SIGN TEST		
Test Statistic S+	**95% Critical Value**	**Null Hypothesis**
19	13	Reject

The test rejected the null hypothesis that the mean value at the site exceeds the threshold, so conclude the site is clean.

APPENDIX D
VSP OUTPUT RESULTS

BENZENE
ND set to one-half MDL

Random sampling locations for comparing a median with a fixed threshold (nonparametric - MARSSIM)

Summary
This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field is also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean or median to a fixed threshold
Type of Sampling Design	Nonparametric
Sample Placement (Location) in the Field	Simple random sampling
Working (Null) Hypothesis	The median(mean) value at the site exceeds the threshold
Formula for calculating number of sampling locations	Sign Test - MARSSIM version
Calculated total number of samples	7972
Number of samples on map [a]	7972
Number of selected sample areas [b]	1
Specified sampling area [c]	300838.47 ft^2
Total cost of sampling [d]	$3,987,000.00

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.
[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.
[d] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.

Primary Sampling Objective
The primary purpose of sampling at this site is to compare a site median or mean value with a fixed threshold. The

working hypothesis (or 'null' hypothesis) is that the median(mean) value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the median(mean) value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative one, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach

A nonparametric random sampling approach was used to determine the number of samples and to specify sampling locations. A nonparametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that typical parametric assumptions may not be true.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

Locating the sample points randomly provides data that are separated by many distances, whereas systematic samples are all equidistant apart. Therefore, random sampling provides more information about the spatial structure of the potential contamination than systematic sampling does. As with systematic sampling, random sampling also provides information regarding the mean value, but there is the possibility that areas of the site will not be represented with the same frequency as if uniform grid sampling were performed.

Number of Total Samples: Calculation Equation and Inputs

The equation used to calculate the number of samples is based on a Sign test (see PNNL 13450 for discussion). For this site, the null hypothesis is rejected in favor of the alternative one if the median(mean) is sufficiently smaller than the threshold. The number of samples to collect is calculated so that if the inputs to the equation are true, the calculated number of samples will cause the null hypothesis to be rejected.

The formula used to calculate the number of samples is:

$$n = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4(SignP - 0.5)^2}$$

where

$$SignP = \Phi\left(\frac{\Delta}{s_{total}}\right)$$

$\Phi(z)$	is the cumulative standard normal distribution on $(-\infty,z)$ (see PNNL-13450 for details),
n	is the number of samples,
S_{total}	is the estimated standard deviation of the measured values including analytical error,
Δ	is the width of the gray region,
α	is the acceptable probability of incorrectly concluding the site median(mean) is less than the threshold,
β	is the acceptable probability of incorrectly concluding the site median(mean) exceeds the threshold,
$Z_{1-\alpha}$	is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is $1-\alpha$,
$Z_{1-\beta}$	is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is $1-\beta$.

Note: MARSSIM suggests that the number of samples should be increased by at least 20% to account for missing or unusable data and uncertainty in the calculated value of n. VSP allows a user-supplied percent overage as discussed in MARSSIM (EPA 2000, p. 5-33).

The values of these inputs that result in the calculated number of sampling locations are:

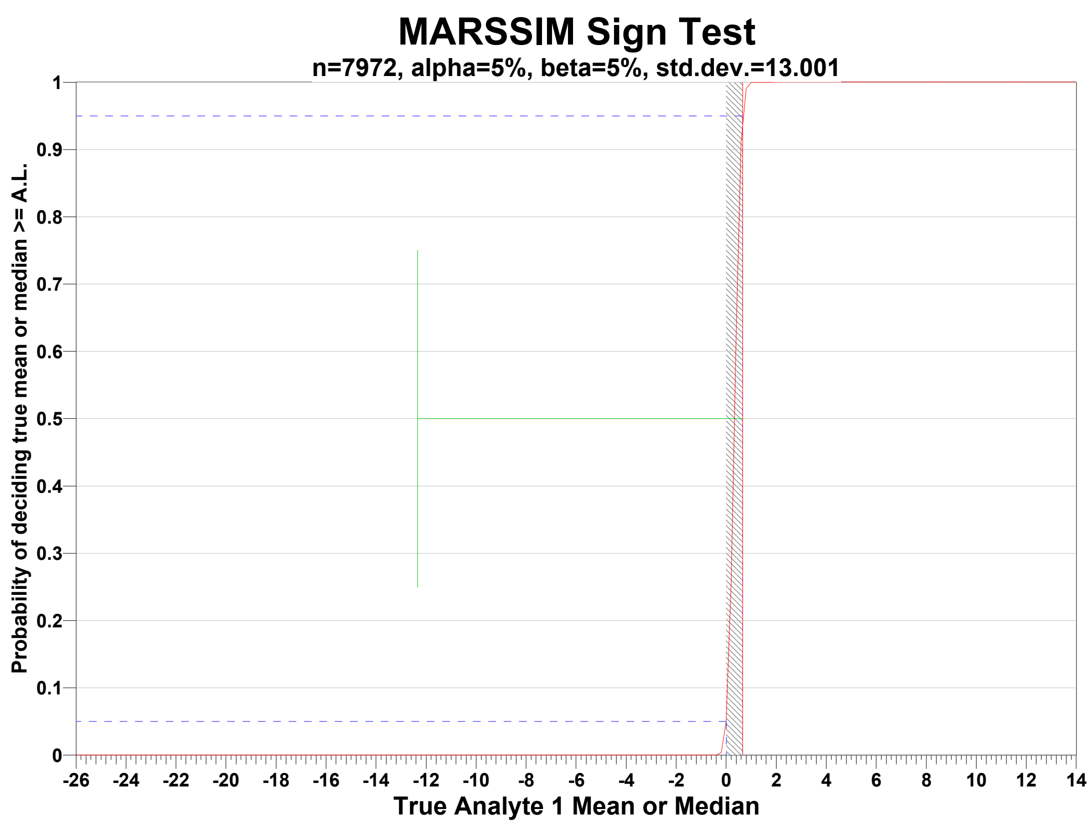
Analyte	n[a]	Parameter					
		S	Δ	α	β	$Z_{1-\alpha}$ [b]	$Z_{1-\beta}$ [c]
Analyte 1	7972	13.001	0.658	0.05	0.05	1.64485	1.64485

[a] The final number of samples has been increased by the MARSSIM Overage of 20%.
[b] This value is automatically calculated by VSP based upon the user defined value of α.

[c] This value is automatically calculated by VSP based upon the user defined value of β.

The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true median(mean) values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the upper horizontal dashed blue line is positioned at 1-α on the vertical axis; the lower horizontal dashed blue line is positioned at β on the vertical axis. The vertical green line is positioned at one standard deviation below the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at β and the upper bound of Δ at 1-α. If any of the inputs change, the number of samples that result in the correct curve changes.



Statistical Assumptions

The assumptions associated with the formulas for computing the number of samples are:

1. the computed sign test statistic is normally distributed,
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected randomly.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the sample locations were selected using a random process.

Sensitivity Analysis

The sensitivity of the calculation of number of samples was explored by varying the standard deviation, lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ > action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples			
AL=0.66	α=5	α=10	α=15

	s=26.002	s=13.001	s=26.002	s=13.001	s=26.002	s=13.001	
	β=5	3166229	791564	2505514	626384	2103364	525845
LBGR=90	β=10	2505514	626384	1922030	480512	1571988	393000
	β=15	2103364	525845	1571988	393000	1257102	314278
	β=5	791564	197897	626384	156600	525845	131465
LBGR=80	β=10	626384	156600	480512	120131	393000	98253
	β=15	525845	131465	393000	98253	314278	78573
	β=5	351810	87958	278396	69604	233712	58432
LBGR=70	β=10	278396	69604	213563	53394	174669	43671
	β=15	233712	58432	174669	43671	139682	34923

s = Standard Deviation
LBGR = Lower Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ > action level
α = Alpha (%), Probability of mistakenly concluding that μ < action level
AL = Action Level (Threshold)

Cost of Sampling
The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is $3,987,000.00, which averages out to a per sample cost of $500.13. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**7972 Samples**
Field collection costs		$100.00	$797,200.00
Analytical costs	$400.00	$400.00	$3,188,800.00
Sum of Field & Analytical costs		**$500.00**	**$3,986,000.00**
Fixed planning and validation costs			$1,000.00
Total cost			**$3,987,000.00**

Data Analysis for Analyte 1
The following data points were entered by the user for analysis.

Analyte 1										
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	0.001	0.001	0.001	0.001	0.0015	0.0055	0.08625	0.125	0.1315	0.1315
10	0.133	0.133	0.1345	0.1345	0.1375	0.1375	0.2	0.2	0.2	0.2
20	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.29
30	0.3	0.3	0.38	0.431	0.681	4	6.2	12	15	16
40	81									

SUMMARY STATISTICS for Analyte 1	
n	41
Min	0.001

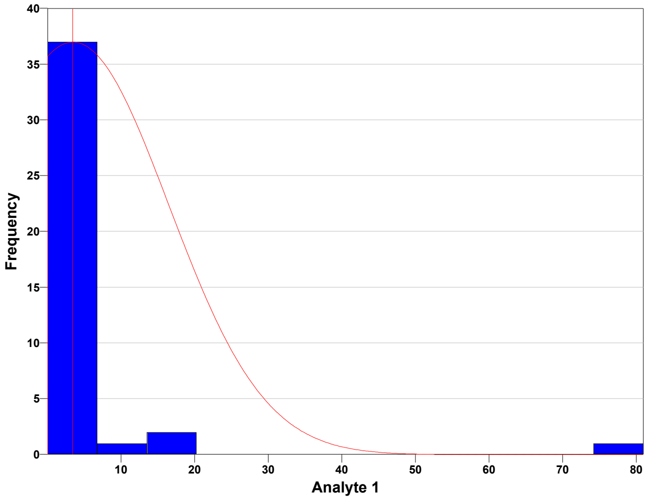
<table>
<tr><td colspan="4">Max</td><td colspan="5">81</td></tr>
<tr><td colspan="4">Range</td><td colspan="5">80.999</td></tr>
<tr><td colspan="4">Mean</td><td colspan="5">3.4263</td></tr>
<tr><td colspan="4">Median</td><td colspan="5">0.2</td></tr>
<tr><td colspan="4">Variance</td><td colspan="5">169.02</td></tr>
<tr><td colspan="4">StdDev</td><td colspan="5">13.001</td></tr>
<tr><td colspan="4">Std Error</td><td colspan="5">2.0304</td></tr>
<tr><td colspan="4">Skewness</td><td colspan="5">5.619</td></tr>
<tr><td colspan="4">Interquartile Range</td><td colspan="5">0.16775</td></tr>
<tr><td colspan="9">Percentiles</td></tr>
<tr><td>1%</td><td>5%</td><td>10%</td><td>25%</td><td>50%</td><td>75%</td><td>90%</td><td>95%</td><td>99%</td></tr>
<tr><td>0.001</td><td>0.001</td><td>0.0011</td><td>0.1323</td><td>0.2</td><td>0.3</td><td>10.84</td><td>15.9</td><td>81</td></tr>
</table>

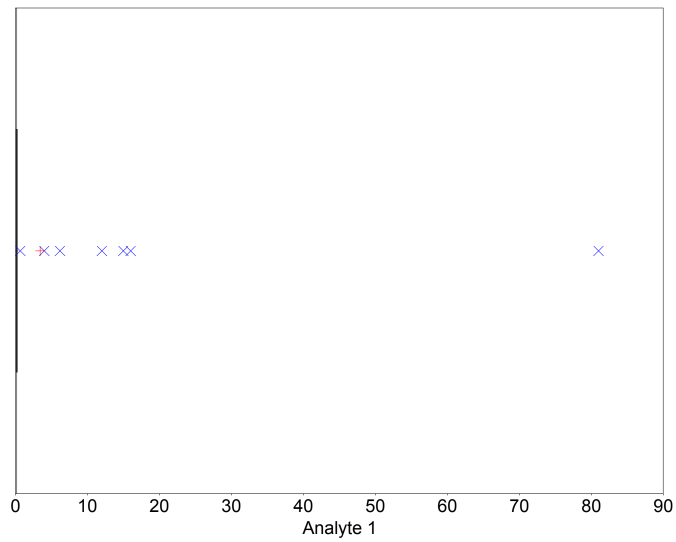
Data Plots
Three graphical displays of the data are shown below: the Histogram, the Box and Whiskers plot, and the Quantile-Quantile (Q-Q) plot.

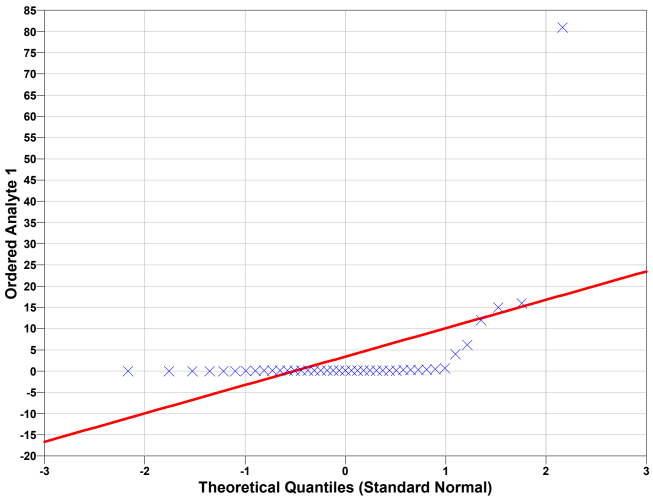
The Histogram is a plot of the fraction of the n observed data that fall within specified data “bins.” A histogram is generated by dividing the x axis (range of the observed data values) into "bins" and displaying the number of data in each bin as the height of a bar for the bin. The area of the bar is the fraction of the n data values that lie within the bin. The sum of the fractions for all bins equals one. A histogram is used to assess how the n data are distributed (spread) over their range of values. If the histogram is more or less symmetric and bell shaped, then the data may be normally distributed.

The Box and Whiskers plot is composed of a central box divided by a line, and with two lines extending out from the box, called the "whiskers". The line through the box is drawn at the median of the n data observed. The two ends of the box represent the 25^{th} and 75^{th} percentiles of the n data values, which are also called the lower and upper quartiles, respectively, of the data set. The sample mean (mean of the n data) is shown as a "+" sign. The upper whisker extends to the largest data value that is less than the upper quartile plus 1.5 times the interquartile range (upper quartile minus the lower quartile). The lower whisker extends to the smallest data value that is greater than the lower quartile minus 1.5 times the interquartile range. Extreme data values (greater or smaller than the ends of the whiskers) are plotted individually. A Box and Whiskers plot is used to assess the symmetry of the distribution of the data set. If the distribution is symmetrical, the box is divided into two equal halves by the median, the whiskers will be the same length, and the number of extreme data points will be distributed equally on either end of the plot.

The Q-Q plot graphs the quantiles of a set of n data against the quantiles of a specific distribution. We show here only the Q-Q plot for an assumed normal distribution. The p^{th} quantile of a distribution of data is the data value, x_p, for which a fraction p of the distribution is less than x_p. If the data plotted on the normal distribution Q-Q plot closely follow a straight line, even at the ends of the line, then the data may be assumed to be normally distributed. If the data points deviate substantially from a linear line, then the data are not normally distributed.







For more information on these three plots consult Guidance for Data Quality Assessment, EPA QA/G-9, pgs 2.3-1 through 2.3-12. (http://www.epa.gov/quality/qa-docs.html).

Tests for Analyte 1
A goodness-of-fit test was performed to test whether the data set had been drawn from an underlying normal distribution. The Shapiro-Wilk (SW) test was used to test the null hypothesis that the data are normally distributed. The test was conducted at the 5% significance level, i.e., the probability the test incorrectly rejects the null hypothesis was set at 0.05.

NORMAL DISTRIBUTION TEST	
Shapiro-Wilk Test Statistic	0.2913
Shapiro-Wilk 5% Critical Value	0.941

The calculated SW test statistic is less than the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the data are normal, or in other words the data do not appear to follow a normal distribution at the 5% level of significance. The Q-Q plot displayed above should be used to further assess the normality of the data.

Upper Confidence Limit on the True Mean
Two methods were used to compute the upper confidence limit (UCL) on the mean. The first is a parametric method that assumes a normal distribution. The second is the Chebyshev method, which requires no distributional assumption.

UCLs ON THE MEAN	
95% Parametric UCL	6.8451

95% Non-Parametric (Chebyshev) UCL	12.277

Because the data do not appear to be normally distributed according to the goodness-of-fit test performed above, the non-parametric UCL (12.28) may be a more accurate upper confidence limit on the true mean.

MARSSIM Sign Test
The Sign test was performed in accordance with the guidance given in section 8.3.2 of MARSSIM. Each measurement was subtracted from the action level to obtain n differences $d_i = AL - X_i$. Any differences of zero were discarded from consideration and the sample size was reduced accordingly. The test statistic S+ was calculated by counting the positive differences. S+ was then compared with the critical value k, which was obtained from Table I.3 in Appendix I of MARSSIM.

If $S+ > k$, then the null hypothesis is rejected.

MARSSIM SIGN TEST		
Test Statistic S+	**95% Critical Value**	**Null Hypothesis**
34	26	Reject

The test rejected the null hypothesis that the mean value at the site exceeds the threshold, so conclude the site is clean.

APPENDIX D
VSP OUTPUT RESULTS

BENZENE

Random sampling locations for comparing a median with a fixed threshold (nonparametric - MARSSIM)

Summary
This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field is also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean or median to a fixed threshold
Type of Sampling Design	Nonparametric
Sample Placement (Location) in the Field	Simple random sampling
Working (Null) Hypothesis	The median(mean) value at the site exceeds the threshold
Formula for calculating number of sampling locations	Sign Test - MARSSIM version
Calculated total number of samples	7934
Number of samples on map [a]	7934
Number of selected sample areas [b]	1
Specified sampling area [c]	300838.47 ft^2
Total cost of sampling [d]	$3,968,000.00

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.
[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.
[d] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.

Primary Sampling Objective
The primary purpose of sampling at this site is to compare a site median or mean value with a fixed threshold. The

working hypothesis (or 'null' hypothesis) is that the median(mean) value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the median(mean) value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative one, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach
A nonparametric random sampling approach was used to determine the number of samples and to specify sampling locations. A nonparametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that typical parametric assumptions may not be true.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

Locating the sample points randomly provides data that are separated by many distances, whereas systematic samples are all equidistant apart. Therefore, random sampling provides more information about the spatial structure of the potential contamination than systematic sampling does. As with systematic sampling, random sampling also provides information regarding the mean value, but there is the possibility that areas of the site will not be represented with the same frequency as if uniform grid sampling were performed.

Number of Total Samples: Calculation Equation and Inputs
The equation used to calculate the number of samples is based on a Sign test (see PNNL 13450 for discussion). For this site, the null hypothesis is rejected in favor of the alternative one if the median(mean) is sufficiently smaller than the threshold. The number of samples to collect is calculated so that if the inputs to the equation are true, the calculated number of samples will cause the null hypothesis to be rejected.

The formula used to calculate the number of samples is:

$$n = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4(SignP - 0.5)^2}$$

where

$$SignP = \Phi\left(\frac{\Delta}{s_{total}}\right)$$

$\Phi(z)$ is the cumulative standard normal distribution on $(-\infty,z)$ (see PNNL-13450 for details),
n is the number of samples,
S_{total} is the estimated standard deviation of the measured values including analytical error,
Δ is the width of the gray region,
α is the acceptable probability of incorrectly concluding the site median(mean) is less than the threshold,
β is the acceptable probability of incorrectly concluding the site median(mean) exceeds the threshold,
$Z_{1-\alpha}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is $1-\alpha$,
$Z_{1-\beta}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is $1-\beta$.

Note: MARSSIM suggests that the number of samples should be increased by at least 20% to account for missing or unusable data and uncertainty in the calculated value of n. VSP allows a user-supplied percent overage as discussed in MARSSIM (EPA 2000, p. 5-33).

The values of these inputs that result in the calculated number of sampling locations are:

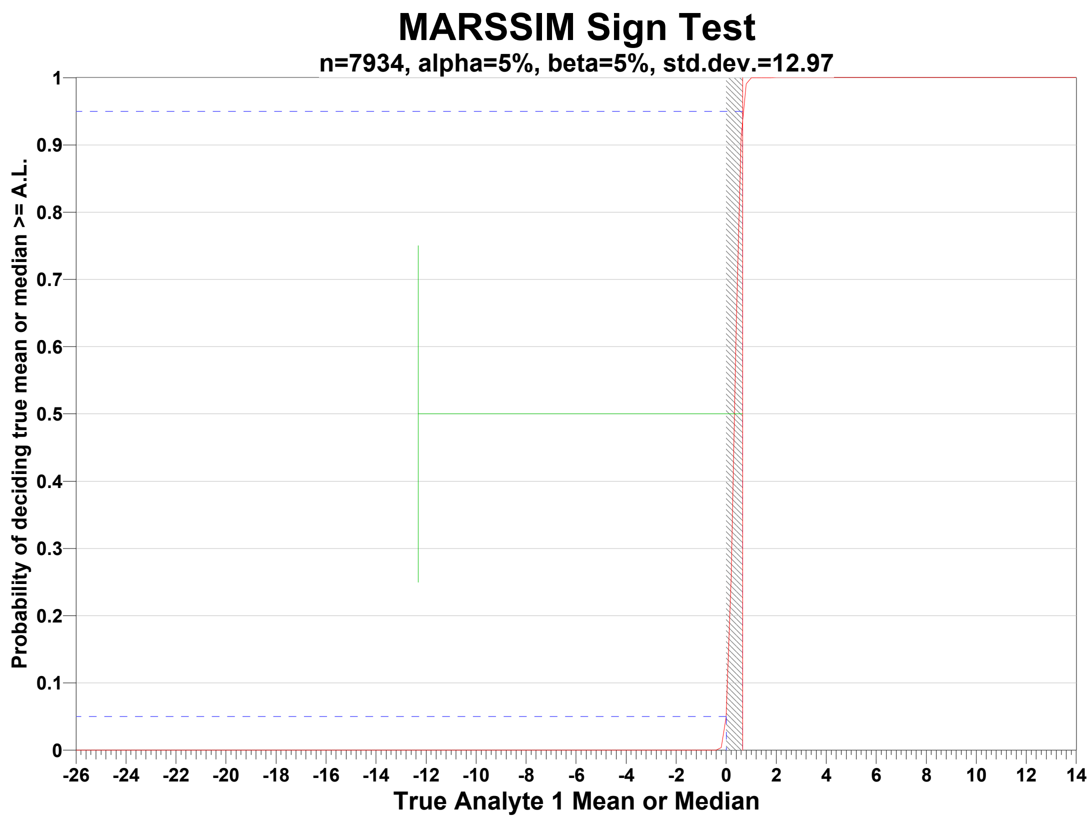
Analyte	**n**[a]	**Parameter**					
		S	**Δ**	**α**	**β**	$Z_{1-\alpha}$ [b]	$Z_{1-\beta}$ [c]
Analyte 1	7934	12.97	0.658	0.05	0.05	1.64485	1.64485

[a] The final number of samples has been increased by the MARSSIM Overage of 20%.
[b] This value is automatically calculated by VSP based upon the user defined value of α.

c This value is automatically calculated by VSP based upon the user defined value of β.

The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true median(mean) values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the upper horizontal dashed blue line is positioned at 1-α on the vertical axis; the lower horizontal dashed blue line is positioned at β on the vertical axis. The vertical green line is positioned at one standard deviation below the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at β and the upper bound of Δ at 1-α. If any of the inputs change, the number of samples that result in the correct curve changes.



Statistical Assumptions

The assumptions associated with the formulas for computing the number of samples are:

1. the computed sign test statistic is normally distributed,
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected randomly.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the sample locations were selected using a random process.

Sensitivity Analysis

The sensitivity of the calculation of number of samples was explored by varying the standard deviation, lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ > action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples			
AL=0.66	α=5	α=10	α=15

	s=25.94	s=12.97	s=25.94	s=12.97	s=25.94	s=12.97	
	β=5	3151148	787793	2493580	623399	2093345	523341
LBGR=90	β=10	2493580	623399	1912875	478222	1564500	391128
	β=15	2093345	523341	1564500	391128	1251116	312782
	β=5	787793	196954	623399	155855	523341	130839
LBGR=80	β=10	623399	155855	478222	119560	391128	97785
	β=15	523341	130839	391128	97785	312782	78198
	β=5	350134	87539	277070	69273	232599	58154
LBGR=70	β=10	277070	69273	212546	53140	173837	43462
	β=15	232599	58154	173837	43462	139016	34757

s = Standard Deviation
LBGR = Lower Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ > action level
α = Alpha (%), Probability of mistakenly concluding that μ < action level
AL = Action Level (Threshold)

Cost of Sampling
The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is $3,968,000.00, which averages out to a per sample cost of $500.13. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**7934 Samples**
Field collection costs		$100.00	$793,400.00
Analytical costs	$400.00	$400.00	$3,173,600.00
Sum of Field & Analytical costs		**$500.00**	**$3,967,000.00**
Fixed planning and validation costs			$1,000.00
Total cost			**$3,968,000.00**

Data Analysis for Analyte 1
The following data points were entered by the user for analysis.

Analyte 1										
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	0.002	0.002	0.002	0.002	0.003	0.011	0.1725	0.25	0.263	0.263
10	0.266	0.266	0.269	0.269	0.275	0.275	0.29	0.38	0.4	0.4
20	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
30	0.4	0.431	0.6	0.6	0.681	4	6.2	12	15	16
40	81									

SUMMARY STATISTICS for Analyte 1	
n	41
Min	0.002

<table>
<tr><td colspan="4">Max</td><td colspan="5">81</td></tr>
<tr><td colspan="4">Range</td><td colspan="5">80.998</td></tr>
<tr><td colspan="4">Mean</td><td colspan="5">3.5359</td></tr>
<tr><td colspan="4">Median</td><td colspan="5">0.4</td></tr>
<tr><td colspan="4">Variance</td><td colspan="5">168.3</td></tr>
<tr><td colspan="4">StdDev</td><td colspan="5">12.973</td></tr>
<tr><td colspan="4">Std Error</td><td colspan="5">2.0261</td></tr>
<tr><td colspan="4">Skewness</td><td colspan="5">5.6299</td></tr>
<tr><td colspan="4">Interquartile Range</td><td colspan="5">0.151</td></tr>
<tr><td colspan="9">Percentiles</td></tr>
<tr><td>1%</td><td>5%</td><td>10%</td><td>25%</td><td>50%</td><td>75%</td><td>90%</td><td>95%</td><td>99%</td></tr>
<tr><td>0.002</td><td>0.002</td><td>0.0022</td><td>0.2645</td><td>0.4</td><td>0.4155</td><td>10.84</td><td>15.9</td><td>81</td></tr>
</table>

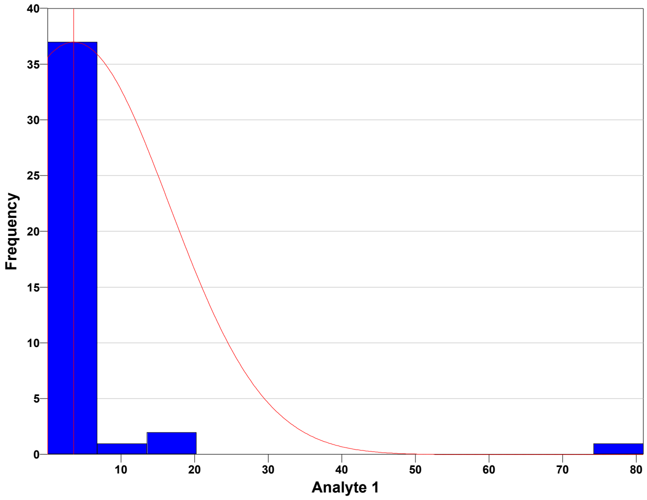
Data Plots

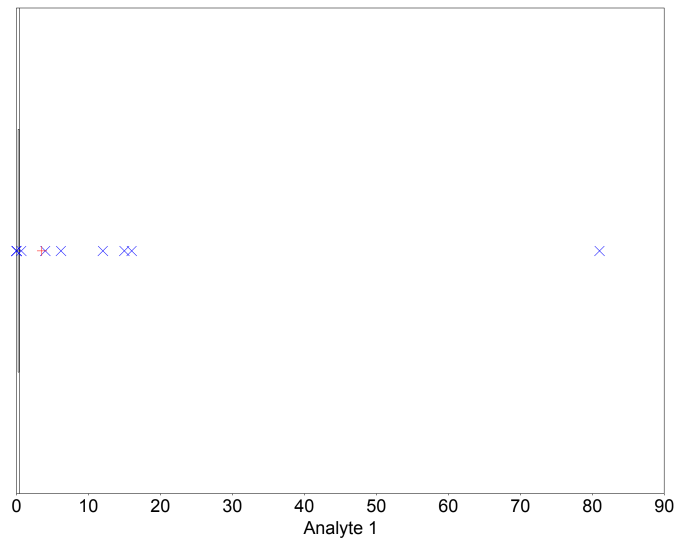
Three graphical displays of the data are shown below: the Histogram, the Box and Whiskers plot, and the Quantile-Quantile (Q-Q) plot.

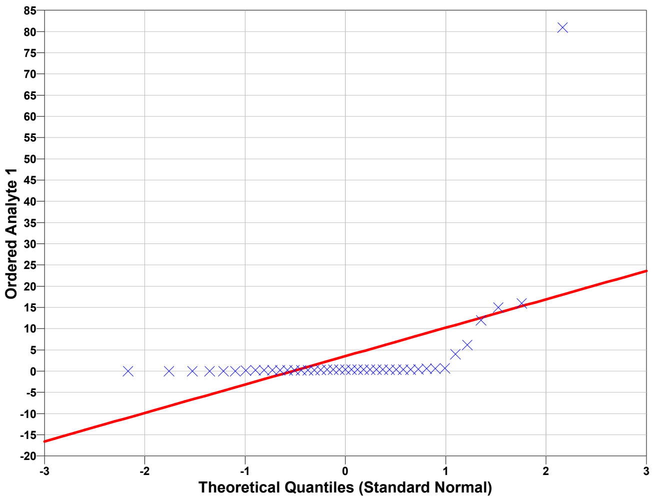
The Histogram is a plot of the fraction of the n observed data that fall within specified data “bins.” A histogram is generated by dividing the x axis (range of the observed data values) into "bins" and displaying the number of data in each bin as the height of a bar for the bin. The area of the bar is the fraction of the n data values that lie within the bin. The sum of the fractions for all bins equals one. A histogram is used to assess how the n data are distributed (spread) over their range of values. If the histogram is more or less symmetric and bell shaped, then the data may be normally distributed.

The Box and Whiskers plot is composed of a central box divided by a line, and with two lines extending out from the box, called the "whiskers". The line through the box is drawn at the median of the n data observed. The two ends of the box represent the 25th and 75th percentiles of the n data values, which are also called the lower and upper quartiles, respectively, of the data set. The sample mean (mean of the n data) is shown as a "+" sign. The upper whisker extends to the largest data value that is less than the upper quartile plus 1.5 times the interquartile range (upper quartile minus the lower quartile). The lower whisker extends to the smallest data value that is greater than the lower quartile minus 1.5 times the interquartile range. Extreme data values (greater or smaller than the ends of the whiskers) are plotted individually. A Box and Whiskers plot is used to assess the symmetry of the distribution of the data set. If the distribution is symmetrical, the box is divided into two equal halves by the median, the whiskers will be the same length, and the number of extreme data points will be distributed equally on either end of the plot.

The Q-Q plot graphs the quantiles of a set of n data against the quantiles of a specific distribution. We show here only the Q-Q plot for an assumed normal distribution. The pth quantile of a distribution of data is the data value, x_n, for which a fraction p of the distribution is less than x_n. If the data plotted on the normal distribution Q-Q plot closely follow a straight line, even at the ends of the line, then the data may be assumed to be normally distributed. If the data points deviate substantially from a linear line, then the data are not normally distributed.







For more information on these three plots consult Guidance for Data Quality Assessment, EPA QA/G-9, pgs 2.3-1 through 2.3-12. (http://www.epa.gov/quality/qa-docs.html).

Tests for Analyte 1

A goodness-of-fit test was performed to test whether the data set had been drawn from an underlying normal distribution. The Shapiro-Wilk (SW) test was used to test the null hypothesis that the data are normally distributed. The test was conducted at the 5% significance level, i.e., the probability the test incorrectly rejects the null hypothesis was set at 0.05.

NORMAL DISTRIBUTION TEST	
Shapiro-Wilk Test Statistic	0.2928
Shapiro-Wilk 5% Critical Value	0.941

The calculated SW test statistic is less than the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the data are normal, or in other words the data do not appear to follow a normal distribution at the 5% level of significance. The Q-Q plot displayed above should be used to further assess the normality of the data.

Upper Confidence Limit on the True Mean

Two methods were used to compute the upper confidence limit (UCL) on the mean. The first is a parametric method that assumes a normal distribution. The second is the Chebyshev method, which requires no distributional assumption.

UCLs ON THE MEAN	
95% Parametric UCL	6.9475

95% Non-Parametric (Chebyshev) UCL	12.367

Because the data do not appear to be normally distributed according to the goodness-of-fit test performed above, the non-parametric UCL (12.37) may be a more accurate upper confidence limit on the true mean.

MARSSIM Sign Test
The Sign test was performed in accordance with the guidance given in section 8.3.2 of MARSSIM. Each measurement was subtracted from the action level to obtain *n* differences $d_i = AL - X_i$. Any differences of zero were discarded from consideration and the sample size was reduced accordingly. The test statistic S+ was calculated by counting the positive differences. S+ was then compared with the critical value *k*, which was obtained from Table I.3 in Appendix I of MARSSIM.

If $S+ > k$, then the null hypothesis is rejected.

MARSSIM SIGN TEST		
Test Statistic S+	**95% Critical Value**	**Null Hypothesis**
34	26	Reject

The test rejected the null hypothesis that the mean value at the site exceeds the threshold, so conclude the site is clean.

APPENDIX D
VSP OUTPUT RESULTS

BENZO(A)PYRENE
ND set to one-half MDL

Random sampling locations for comparing a median with a fixed threshold (nonparametric - MARSSIM)

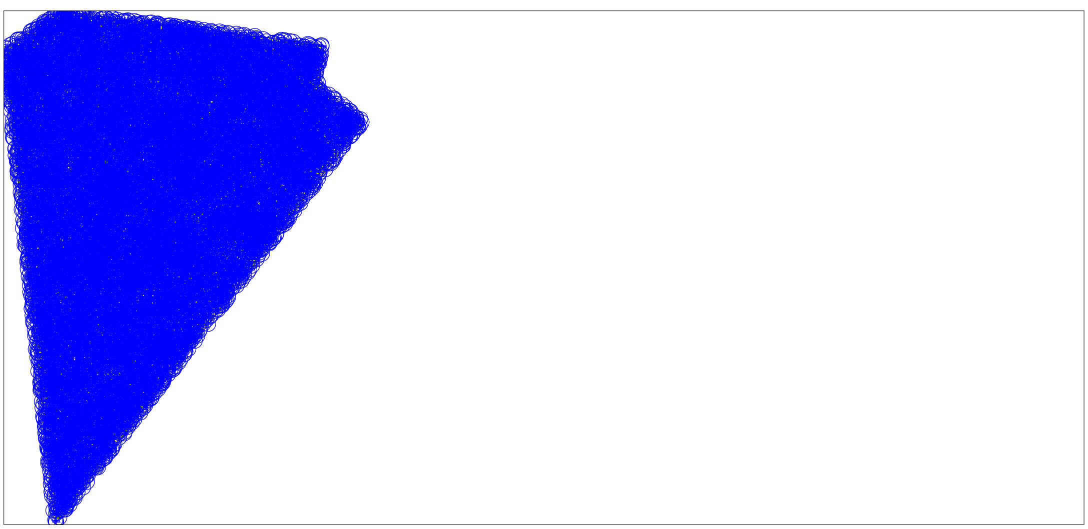
Summary

This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field is also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean or median to a fixed threshold
Type of Sampling Design	Nonparametric
Sample Placement (Location) in the Field	Simple random sampling
Working (Null) Hypothesis	The median(mean) value at the site exceeds the threshold
Formula for calculating number of sampling locations	Sign Test - MARSSIM version
Calculated total number of samples	2971565
Number of samples on map [a]	12000
Number of selected sample areas [b]	1
Specified sampling area [c]	300838.47 ft^2
Total cost of sampling [d]	$1,485,783,500.00

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.
[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.
[d] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.



Primary Sampling Objective

The primary purpose of sampling at this site is to compare a site median or mean value with a fixed threshold. The

working hypothesis (or 'null' hypothesis) is that the median(mean) value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the median(mean) value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative one, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach
A nonparametric random sampling approach was used to determine the number of samples and to specify sampling locations. A nonparametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that typical parametric assumptions may not be true.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

Locating the sample points randomly provides data that are separated by many distances, whereas systematic samples are all equidistant apart. Therefore, random sampling provides more information about the spatial structure of the potential contamination than systematic sampling does. As with systematic sampling, random sampling also provides information regarding the mean value, but there is the possibility that areas of the site will not be represented with the same frequency as if uniform grid sampling were performed.

Number of Total Samples: Calculation Equation and Inputs
The equation used to calculate the number of samples is based on a Sign test (see PNNL 13450 for discussion). For this site, the null hypothesis is rejected in favor of the alternative one if the median(mean) is sufficiently smaller than the threshold. The number of samples to collect is calculated so that if the inputs to the equation are true, the calculated number of samples will cause the null hypothesis to be rejected.

The formula used to calculate the number of samples is:

$$n = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4(SignP - 0.5)^2}$$

where

$$SignP = \Phi\left(\frac{\Delta}{s_{total}}\right)$$

$\Phi(z)$ is the cumulative standard normal distribution on $(-\infty, z)$ (see PNNL-13450 for details),
n is the number of samples,
S_{total} is the estimated standard deviation of the measured values including analytical error,
Δ is the width of the gray region,
α is the acceptable probability of incorrectly concluding the site median(mean) is less than the threshold,
β is the acceptable probability of incorrectly concluding the site median(mean) exceeds the threshold,
$Z_{1-\alpha}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is $1-\alpha$,
$Z_{1-\beta}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is $1-\beta$.

Note: MARSSIM suggests that the number of samples should be increased by at least 20% to account for missing or unusable data and uncertainty in the calculated value of n. VSP allows a user-supplied percent overage as discussed in MARSSIM (EPA 2000, p. 5-33).

The values of these inputs that result in the calculated number of sampling locations are:

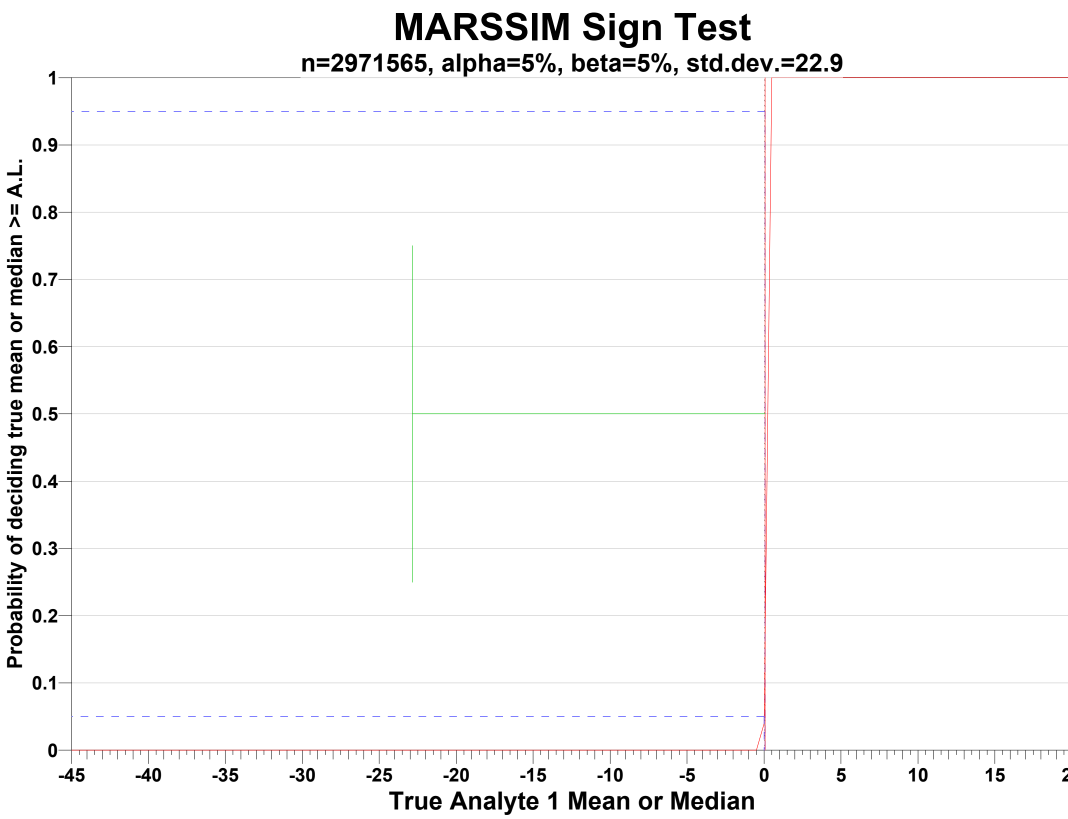
Analyte	n[a]	Parameter					
		S	Δ	α	β	$Z_{1-\alpha}$ [b]	$Z_{1-\beta}$ [c]
Analyte 1	2971565	22.9	0.06	0.05	0.05	1.64485	1.64485

[a] The final number of samples has been increased by the MARSSIM Overage of 20%.
[b] This value is automatically calculated by VSP based upon the user defined value of α.

[c] This value is automatically calculated by VSP based upon the user defined value of β.

The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true median(mean) values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the upper horizontal dashed blue line is positioned at 1-α on the vertical axis; the lower horizontal dashed blue line is positioned at β on the vertical axis. The vertical green line is positioned at one standard deviation below the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at β and the upper bound of Δ at 1-α. If any of the inputs change, the number of samples that result in the correct curve changes.



Statistical Assumptions
The assumptions associated with the formulas for computing the number of samples are:
1. the computed sign test statistic is normally distributed,
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected randomly.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the sample locations were selected using a random process.

Sensitivity Analysis
The sensitivity of the calculation of number of samples was explored by varying the standard deviation, lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ > action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples			
AL=0.062	α=5	α=10	α=15

	s=45.8	s=22.9	s=45.8	s=22.9	s=45.8	s=22.9	
	β=5	1113174394	278293605	880881767	220220446	739495122	184873785
LBGR=90	β=10	880881767	220220446	675741927	168935486	552675140	138168788
	β=15	739495122	184873785	552675140	138168788	441968672	110492171
	β=5	278293605	69573407	220220446	55055116	184873785	46218450
LBGR=80	β=10	220220446	55055116	168935486	42233876	138168788	34542201
	β=15	184873785	46218450	138168788	34542201	110492171	27623045
	β=5	123686051	30921519	97875758	24468944	82166129	20541537
LBGR=70	β=10	97875758	24468944	75082440	18770614	61408353	15352091
	β=15	82166129	20541537	61408353	15352091	49107634	12276911

s = Standard Deviation
LBGR = Lower Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ > action level
α = Alpha (%), Probability of mistakenly concluding that μ < action level
AL = Action Level (Threshold)

Cost of Sampling
The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is $1,485,783,500.00, which averages out to a per sample cost of $500.00. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**2971565 Samples**
Field collection costs		$100.00	$297,156,500.00
Analytical costs	$400.00	$400.00	$1,188,626,000.00
Sum of Field & Analytical costs		**$500.00**	**$1,485,782,500.00**
Fixed planning and validation costs			$1,000.00
Total cost			**$1,485,783,500.00**

Data Analysis for Analyte 1
The following data points were entered by the user for analysis.

Analyte 1										
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	0.312	0.401	3.5	3.5	6.875	7.05	7.15	7.4	7.45	17.7
10	17.9	33.35	35.1	35.85	36.65	36.65	52.5	87.5		

SUMMARY STATISTICS for Analyte 1	
n	18
Min	0.312
Max	87.5
Range	87.188
Mean	22.047

Median	12.575
Variance	523.31
StdDev	22.876
Std Error	5.3919
Skewness	1.5005
Interquartile Range	30.019

Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
0.312	0.312	0.3921	6.031	12.57	36.05	56	87.5	87.5

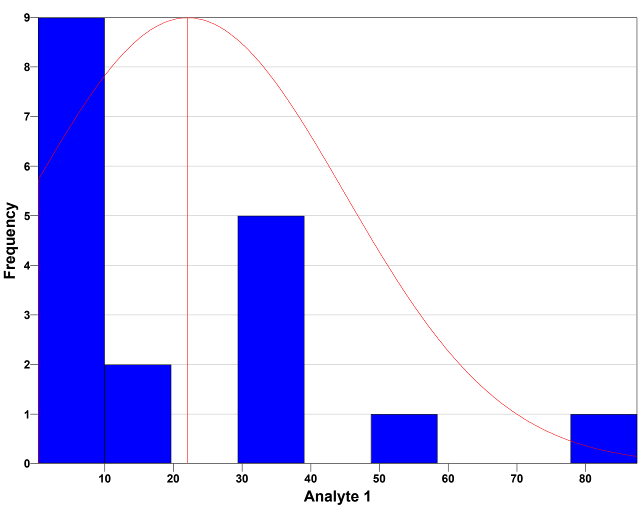
Data Plots

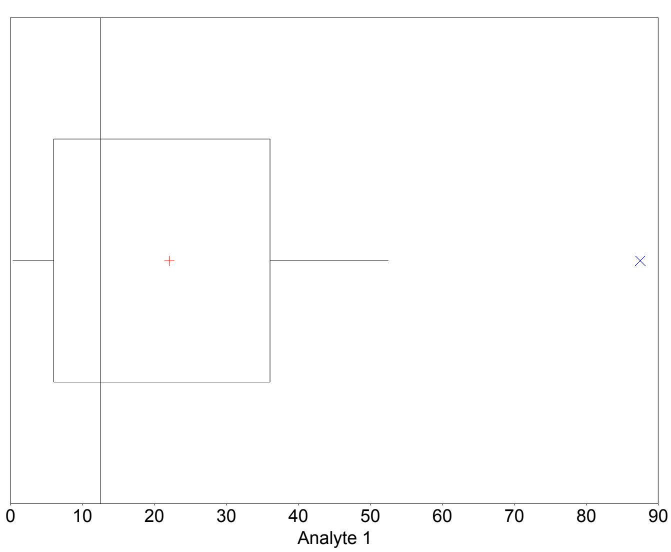
Three graphical displays of the data are shown below: the Histogram, the Box and Whiskers plot, and the Quantile-Quantile (Q-Q) plot.

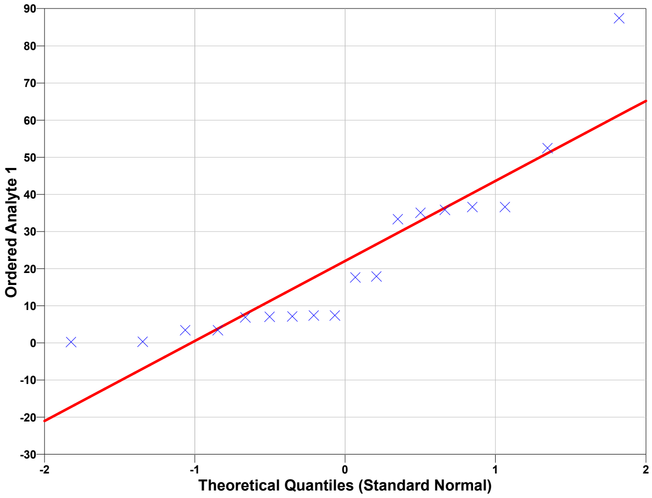
The Histogram is a plot of the fraction of the n observed data that fall within specified data "bins." A histogram is generated by dividing the x axis (range of the observed data values) into "bins" and displaying the number of data in each bin as the height of a bar for the bin. The area of the bar is the fraction of the n data values that lie within the bin. The sum of the fractions for all bins equals one. A histogram is used to assess how the n data are distributed (spread) over their range of values. If the histogram is more or less symmetric and bell shaped, then the data may be normally distributed.

The Box and Whiskers plot is composed of a central box divided by a line, and with two lines extending out from the box, called the "whiskers". The line through the box is drawn at the median of the n data observed. The two ends of the box represent the 25^{th} and 75^{th} percentiles of the n data values, which are also called the lower and upper quartiles, respectively, of the data set. The sample mean (mean of the n data) is shown as a "+" sign. The upper whisker extends to the largest data value that is less than the upper quartile plus 1.5 times the interquartile range (upper quartile minus the lower quartile). The lower whisker extends to the smallest data value that is greater than the lower quartile minus 1.5 times the interquartile range. Extreme data values (greater or smaller than the ends of the whiskers) are plotted individually. A Box and Whiskers plot is used to assess the symmetry of the distribution of the data set. If the distribution is symmetrical, the box is divided into two equal halves by the median, the whiskers will be the same length, and the number of extreme data points will be distributed equally on either end of the plot.

The Q-Q plot graphs the quantiles of a set of n data against the quantiles of a specific distribution. We show here only the Q-Q plot for an assumed normal distribution. The p^{th} quantile of a distribution of data is the data value, x_p, for which a fraction p of the distribution is less than x_p. If the data plotted on the normal distribution Q-Q plot closely follow a straight line, even at the ends of the line, then the data may be assumed to be normally distributed. If the data points deviate substantially from a linear line, then the data are not normally distributed.







For more information on these three plots consult Guidance for Data Quality Assessment, EPA QA/G-9, pgs 2.3-1 through 2.3-12. (http://www.epa.gov/quality/qa-docs.html).

Tests for Analyte 1

A goodness-of-fit test was performed to test whether the data set had been drawn from an underlying normal distribution. The Shapiro-Wilk (SW) test was used to test the null hypothesis that the data are normally distributed. The test was conducted at the 5% significance level, i.e., the probability the test incorrectly rejects the null hypothesis was set at 0.05.

NORMAL DISTRIBUTION TEST	
Shapiro-Wilk Test Statistic	0.823
Shapiro-Wilk 5% Critical Value	0.897

The calculated SW test statistic is less than the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the data are normal, or in other words the data do not appear to follow a normal distribution at the 5% level of significance. The Q-Q plot displayed above should be used to further assess the normality of the data.

Upper Confidence Limit on the True Mean

Two methods were used to compute the upper confidence limit (UCL) on the mean. The first is a parametric method that assumes a normal distribution. The second is the Chebyshev method, which requires no distributional assumption.

UCLs ON THE MEAN	
95% Parametric UCL	31.426
95% Non-Parametric (Chebyshev) UCL	45.549

Because the data do not appear to be normally distributed according to the goodness-of-fit test performed above, the non-parametric UCL (45.55) may be a more accurate upper confidence limit on the true mean.

MARSSIM Sign Test

The Sign test was performed in accordance with the guidance given in section 8.3.2 of MARSSIM. Each measurement was subtracted from the action level to obtain *n* differences $d_i = AL - X_i$. Any differences of zero were discarded from consideration and the sample size was reduced accordingly. The test statistic S+ was calculated by counting the positive differences. S+ was then compared with the critical value *k*, which was obtained from Table I.3 in Appendix I of MARSSIM.

If $S+ > k$, then the null hypothesis is rejected.

MARSSIM SIGN TEST		
Test Statistic S+	**95% Critical Value**	**Null Hypothesis**
0	12	Cannot Reject

The test did not reject the null hypothesis that the mean value at the site exceeds the threshold, so conclude the site is dirty.

APPENDIX D
VSP OUTPUT RESULTS

BENZO(A)PYRENE

Random sampling locations for comparing a median with a fixed threshold (nonparametric - MARSSIM)

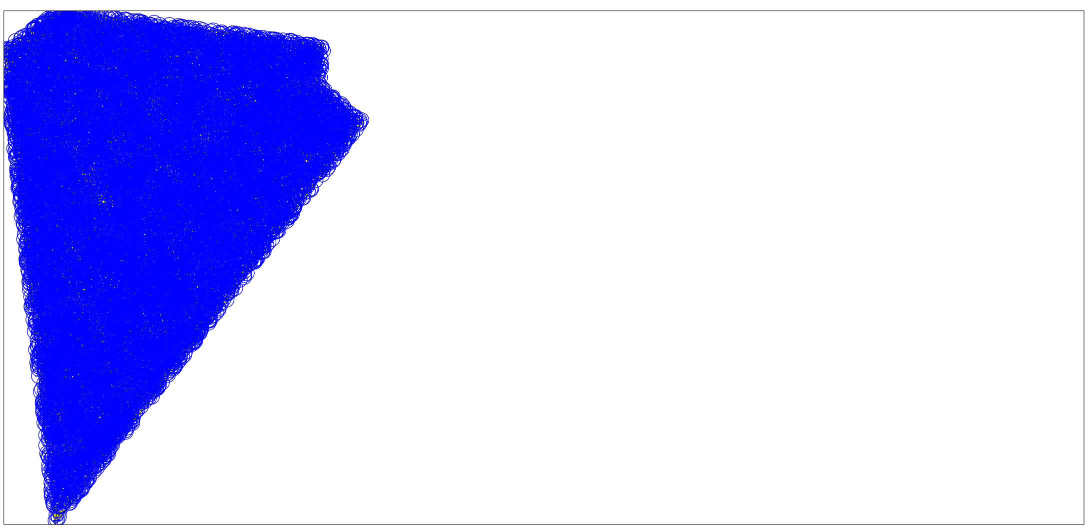
Summary

This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field is also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean or median to a fixed threshold
Type of Sampling Design	Nonparametric
Sample Placement (Location) in the Field	Simple random sampling
Working (Null) Hypothesis	The median(mean) value at the site exceeds the threshold
Formula for calculating number of sampling locations	Sign Test - MARSSIM version
Calculated total number of samples	11886237
Number of samples on map [a]	12000
Number of selected sample areas [b]	1
Specified sampling area [c]	300838.47 ft^2
Total cost of sampling [d]	$5,943,119,500.00

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.
[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.
[d] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.



Primary Sampling Objective

The primary purpose of sampling at this site is to compare a site median or mean value with a fixed threshold. The

working hypothesis (or 'null' hypothesis) is that the median(mean) value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the median(mean) value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative one, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach
A nonparametric random sampling approach was used to determine the number of samples and to specify sampling locations. A nonparametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that typical parametric assumptions may not be true.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

Locating the sample points randomly provides data that are separated by many distances, whereas systematic samples are all equidistant apart. Therefore, random sampling provides more information about the spatial structure of the potential contamination than systematic sampling does. As with systematic sampling, random sampling also provides information regarding the mean value, but there is the possibility that areas of the site will not be represented with the same frequency as if uniform grid sampling were performed.

Number of Total Samples: Calculation Equation and Inputs
The equation used to calculate the number of samples is based on a Sign test (see PNNL 13450 for discussion). For this site, the null hypothesis is rejected in favor of the alternative one if the median(mean) is sufficiently smaller than the threshold. The number of samples to collect is calculated so that if the inputs to the equation are true, the calculated number of samples will cause the null hypothesis to be rejected.

The formula used to calculate the number of samples is:

$$n = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4(SignP - 0.5)^2}$$

where

$$SignP = \Phi\left(\frac{\Delta}{s_{total}}\right)$$

$\Phi(z)$ is the cumulative standard normal distribution on $(-\infty,z)$ (see PNNL-13450 for details),
n is the number of samples,
S_{total} is the estimated standard deviation of the measured values including analytical error,
Δ is the width of the gray region,
α is the acceptable probability of incorrectly concluding the site median(mean) is less than the threshold,
β is the acceptable probability of incorrectly concluding the site median(mean) exceeds the threshold,
$Z_{1-\alpha}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is $1-\alpha$,
$Z_{1-\beta}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is $1-\beta$.

Note: MARSSIM suggests that the number of samples should be increased by at least 20% to account for missing or unusable data and uncertainty in the calculated value of n. VSP allows a user-supplied percent overage as discussed in MARSSIM (EPA 2000, p. 5-33).

The values of these inputs that result in the calculated number of sampling locations are:

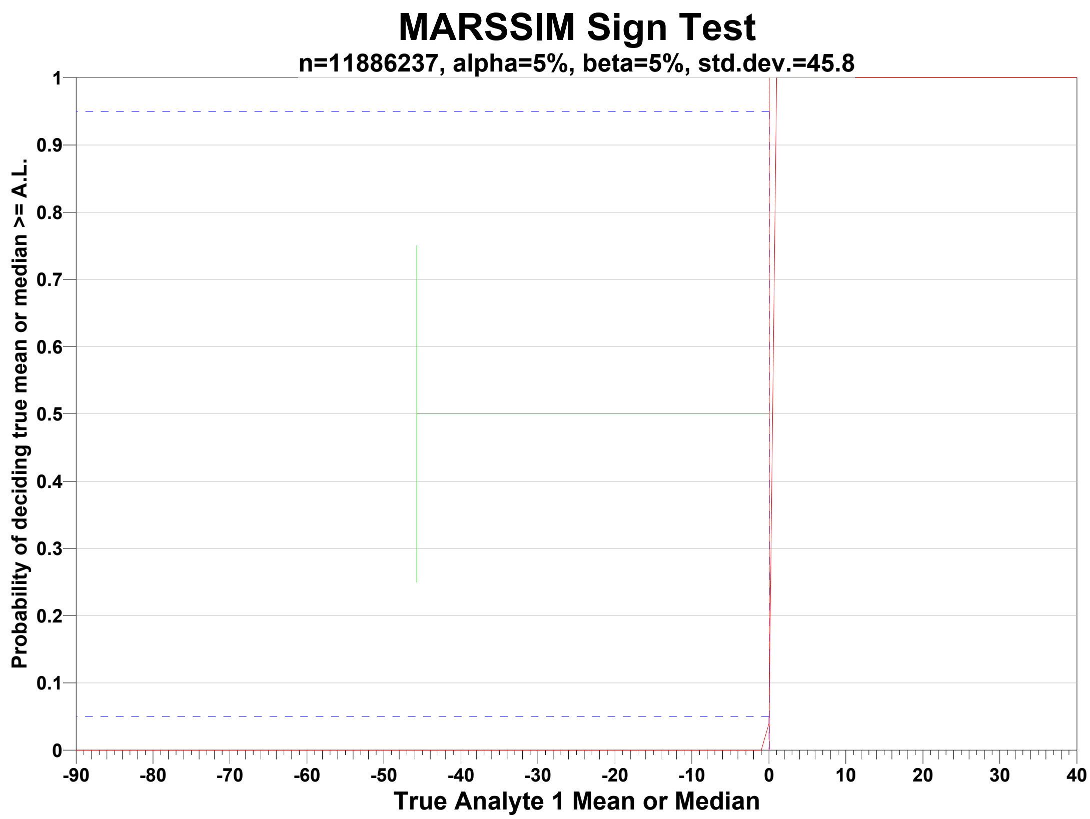
Analyte	n[a]	Parameter					
		S	Δ	α	β	$Z_{1-\alpha}$ [b]	$Z_{1-\beta}$ [c]
Analyte 1	11886237	45.8	0.06	0.05	0.05	1.64485	1.64485

[a] The final number of samples has been increased by the MARSSIM Overage of 20%.
[b] This value is automatically calculated by VSP based upon the user defined value of α.

[c] This value is automatically calculated by VSP based upon the user defined value of β.

The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true median(mean) values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the upper horizontal dashed blue line is positioned at 1-α on the vertical axis; the lower horizontal dashed blue line is positioned at β on the vertical axis. The vertical green line is positioned at one standard deviation below the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at β and the upper bound of Δ at 1-α. If any of the inputs change, the number of samples that result in the correct curve changes.



Statistical Assumptions
The assumptions associated with the formulas for computing the number of samples are:
1. the computed sign test statistic is normally distributed,
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected randomly.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the sample locations were selected using a random process.

Sensitivity Analysis
The sensitivity of the calculation of number of samples was explored by varying the standard deviation, lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ > action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples			
AL=0.062	α=5	α=10	α=15

	s=91.6	s=45.8	s=91.6	s=45.8	s=91.6	s=45.8	
	β=5	4452697554	1113174394	3523527048	880881767	2957980473	739495122
LBGR=90	β=10	3523527048	880881767	2702967692	675741927	2210700543	552675140
	β=15	2957980473	739495122	2210700543	552675140	1767874677	441968672
	β=5	1113174394	278293605	880881767	220220446	739495122	184873785
LBGR=80	β=10	880881767	220220446	675741927	168935486	552675140	138168788
	β=15	739495122	184873785	552675140	138168788	441968672	110492171
	β=5	494744180	123686051	391503011	97875758	328664502	82166129
LBGR=70	β=10	391503011	97875758	300329748	75082440	245633398	61408353
	β=15	328664502	82166129	245633398	61408353	196430523	49107634

s = Standard Deviation
LBGR = Lower Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ > action level
α = Alpha (%), Probability of mistakenly concluding that μ < action level
AL = Action Level (Threshold)

Cost of Sampling
The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is $5,943,119,500.00, which averages out to a per sample cost of $500.00. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**11886237 Samples**
Field collection costs		$100.00	$1,188,623,700.00
Analytical costs	$400.00	$400.00	$4,754,494,800.00
Sum of Field & Analytical costs		**$500.00**	**$5,943,118,500.00**
Fixed planning and validation costs			$1,000.00
Total cost			**$5,943,119,500.00**

Data Analysis for Analyte 1
The following data points were entered by the user for analysis.

Analyte 1										
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	0.312	0.401	7	7	13.75	14.1	14.3	14.8	14.9	35.4
10	35.8	66.7	70.2	71.7	73.3	73.3	105	175		

SUMMARY STATISTICS for Analyte 1	
n	18
Min	0.312
Max	175
Range	174.69
Mean	44.054

<table>
<tr><td colspan="4">Median</td><td colspan="5">25.15</td></tr>
<tr><td colspan="4">Variance</td><td colspan="5">2096.9</td></tr>
<tr><td colspan="4">StdDev</td><td colspan="5">45.792</td></tr>
<tr><td colspan="4">Std Error</td><td colspan="5">10.793</td></tr>
<tr><td colspan="4">Skewness</td><td colspan="5">1.4967</td></tr>
<tr><td colspan="4">Interquartile Range</td><td colspan="5">60.037</td></tr>
<tr><td colspan="9">Percentiles</td></tr>
<tr><td>1%</td><td>5%</td><td>10%</td><td>25%</td><td>50%</td><td>75%</td><td>90%</td><td>95%</td><td>99%</td></tr>
<tr><td>0.312</td><td>0.312</td><td>0.3921</td><td>12.06</td><td>25.15</td><td>72.1</td><td>112</td><td>175</td><td>175</td></tr>
</table>

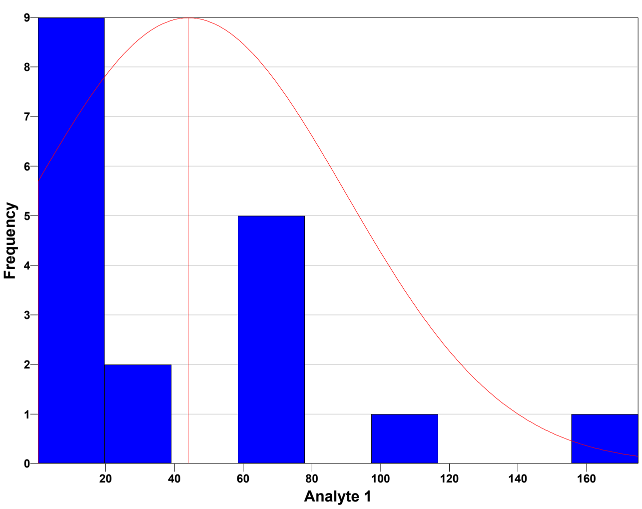
Data Plots

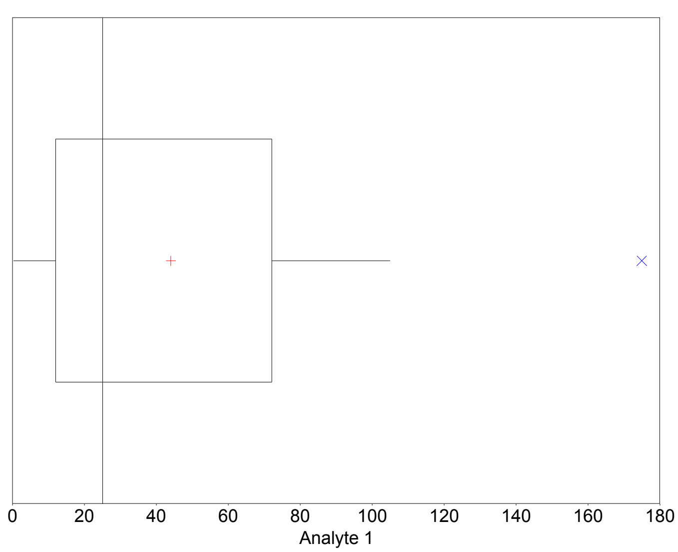
Three graphical displays of the data are shown below: the Histogram, the Box and Whiskers plot, and the Quantile-Quantile (Q-Q) plot.

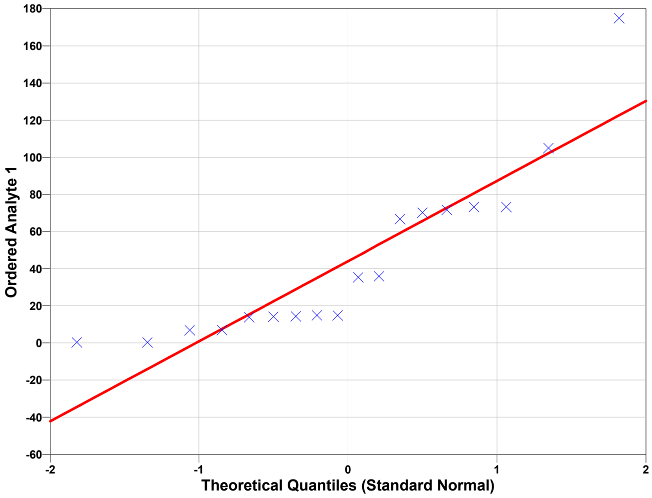
The Histogram is a plot of the fraction of the n observed data that fall within specified data “bins.” A histogram is generated by dividing the x axis (range of the observed data values) into "bins" and displaying the number of data in each bin as the height of a bar for the bin. The area of the bar is the fraction of the n data values that lie within the bin. The sum of the fractions for all bins equals one. A histogram is used to assess how the n data are distributed (spread) over their range of values. If the histogram is more or less symmetric and bell shaped, then the data may be normally distributed.

The Box and Whiskers plot is composed of a central box divided by a line, and with two lines extending out from the box, called the "whiskers". The line through the box is drawn at the median of the n data observed. The two ends of the box represent the 25^{th} and 75^{th} percentiles of the n data values, which are also called the lower and upper quartiles, respectively, of the data set. The sample mean (mean of the n data) is shown as a "+" sign. The upper whisker extends to the largest data value that is less than the upper quartile plus 1.5 times the interquartile range (upper quartile minus the lower quartile). The lower whisker extends to the smallest data value that is greater than the lower quartile minus 1.5 times the interquartile range. Extreme data values (greater or smaller than the ends of the whiskers) are plotted individually. A Box and Whiskers plot is used to assess the symmetry of the distribution of the data set. If the distribution is symmetrical, the box is divided into two equal halves by the median, the whiskers will be the same length, and the number of extreme data points will be distributed equally on either end of the plot.

The Q-Q plot graphs the quantiles of a set of n data against the quantiles of a specific distribution. We show here only the Q-Q plot for an assumed normal distribution. The p^{th} quantile of a distribution of data is the data value, x_p, for which a fraction p of the distribution is less than x_p. If the data plotted on the normal distribution Q-Q plot closely follow a straight line, even at the ends of the line, then the data may be assumed to be normally distributed. If the data points deviate substantially from a linear line, then the data are not normally distributed.







For more information on these three plots consult Guidance for Data Quality Assessment, EPA QA/G-9, pgs 2.3-1 through 2.3-12. (http://www.epa.gov/quality/qa-docs.html).

Tests for Analyte 1
A goodness-of-fit test was performed to test whether the data set had been drawn from an underlying normal distribution. The Shapiro-Wilk (SW) test was used to test the null hypothesis that the data are normally distributed. The test was conducted at the 5% significance level, i.e., the probability the test incorrectly rejects the null hypothesis was set at 0.05.

NORMAL DISTRIBUTION TEST	
Shapiro-Wilk Test Statistic	0.8243
Shapiro-Wilk 5% Critical Value	0.897

The calculated SW test statistic is less than the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the data are normal, or in other words the data do not appear to follow a normal distribution at the 5% level of significance. The Q-Q plot displayed above should be used to further assess the normality of the data.

Upper Confidence Limit on the True Mean
Two methods were used to compute the upper confidence limit (UCL) on the mean. The first is a parametric method that assumes a normal distribution. The second is the Chebyshev method, which requires no distributional assumption.

UCLs ON THE MEAN	
95% Parametric UCL	62.83
95% Non-Parametric (Chebyshev) UCL	91.1

Because the data do not appear to be normally distributed according to the goodness-of-fit test performed above, the non-parametric UCL (91.1) may be a more accurate upper confidence limit on the true mean.

MARSSIM Sign Test
The Sign test was performed in accordance with the guidance given in section 8.3.2 of MARSSIM. Each measurement was subtracted from the action level to obtain n differences $d_i = AL - X_i$. Any differences of zero were discarded from consideration and the sample size was reduced accordingly. The test statistic S+ was calculated by counting the positive differences. S+ was then compared with the critical value k, which was obtained from Table I.3 in Appendix I of MARSSIM.

If $S+ > k$, then the null hypothesis is rejected.

MARSSIM SIGN TEST		
Test Statistic S+	**95% Critical Value**	**Null Hypothesis**
0	12	Cannot Reject

The test did not reject the null hypothesis that the mean value at the site exceeds the threshold, so conclude the site is dirty.

APPENDIX D
VSP OUTPUT RESULTS

XYLENE
ND set to one-half MDL

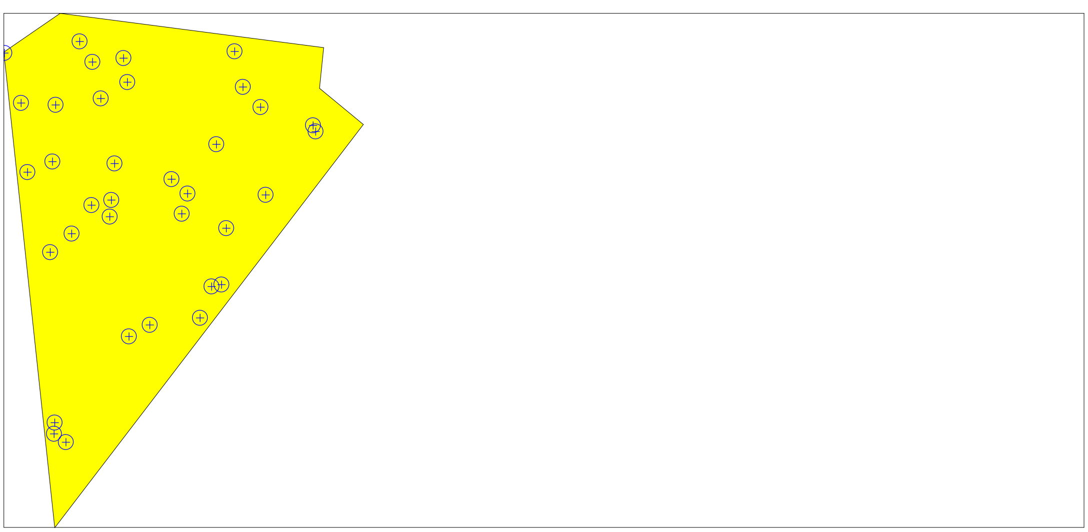
Random sampling locations for comparing a median with a fixed threshold (nonparametric - MARSSIM)

Summary
This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field and a table that lists sampling location coordinates are also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean or median to a fixed threshold
Type of Sampling Design	Nonparametric
Sample Placement (Location) in the Field	Simple random sampling
Working (Null) Hypothesis	The median(mean) value at the site exceeds the threshold
Formula for calculating number of sampling locations	Sign Test - MARSSIM version
Calculated total number of samples	35
Number of samples on map [a]	35
Number of selected sample areas [b]	1
Specified sampling area [c]	300838.47 ft^2
Total cost of sampling [d]	$18,500.00

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.
[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.
[d] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.



Area: Area 1

X Coord	Y Coord	Label	Value	Type	Historical
1787405.0357	10660076.0609	R-SO-4	0.002	Random	
1787370.7357	10660067.1696	R-SO-5	0.1375	Random	
1787432.8457	10660279.1610	R-SO-6	0.1345	Random	
1787585.8420	10660171.8942	R-SO-7	0.1315	Random	
1787471.5215	10659860.7474	R-SO-8	0.133	Random	
1787595.0622	10659930.0696	R-SO-9	0.1375	Random	
1787336.2863	10660018.0751	R-SO-11	0.1315	Random	
1787305.9228	10659672.7112	R-SO-12	0.133	Random	
1787752.6527	10660204.9102	R-SO-13/14 Average	0.08625	Random	
1787260.5657	10660124.1124	R-SO-16	0.001	Random	
1787249.1251	10660243.5238	R-SO-17	0.0055	Random	
1787577.6723	10659927.0333	R-SO-18	0.125	Random	
1787508.9699	10660112.0356	R-SO-19	0.1345	Random	
1787303.5795	10660142.4705	R-SO-20	0.139	Random	
1787402.3024	10660047.3413	R-SO-21	0.133	Random	
1787350.2563	10660349.4344	R-SO-22	0.068	Random	
1787435.2642	10659840.7454	R-ERM-SB-6	170	Random	
1787372.3336	10660314.0779	R-ERM-SB-8	63	Random	
1787557.8804	10659872.9702	R-ERM-SB-11	47	Random	
1787662.5667	10660236.2266	R-ERM-SB-12	240	Random	
1787307.4005	10659692.3311	T-SO-1	0.001	Random	
1787526.4680	10660052.3762	T-SO-2	0.001	Random	
1787410.2811	10660139.1280	T-2 4.5'	0.3	Random	
1787631.7021	10660271.0706	T-4 5'	0.3	Random	
1787671.0153	10660084.9671	T-MW1 15-17'	8.1	Random	
1787617.4162	10660331.9744	T-MW1 39-40'	0.2	Random	
1787326.6719	10659658.7708	T-B3 10-12'	2.5	Random	
1787426.2016	10660320.3638	T-B3 42-43'	0.2	Random	
1787220.5149	10660329.7118	T-MW2 14-16'	6	Random	
1787299.2901	10659985.9315	T-MW2 40-42'	0.2	Random	
1787757.0828	10660194.4019	T-B4 10-12'	5.8	Random	
1787603.2997	10660027.2192	T-B4 42'	0.2	Random	
1787308.6786	10660240.1985	T-B4 0-2'	0.2	Random	
1787386.8040	10660251.1211	T-B4 12-14	0.2	Random	
1787536.1797	10660087.2241	T-MW3 17-19'	1500	Random	

Primary Sampling Objective
The primary purpose of sampling at this site is to compare a site median or mean value with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the median(mean) value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the median(mean) value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative one, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach
A nonparametric random sampling approach was used to determine the number of samples and to specify sampling locations. A nonparametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that typical parametric assumptions may not be true.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

Locating the sample points randomly provides data that are separated by many distances, whereas systematic samples are all equidistant apart. Therefore, random sampling provides more information about the spatial structure of the potential contamination than systematic sampling does. As with systematic sampling, random sampling also provides information regarding the mean value, but there is the possibility that areas of the site will not be represented with the same frequency as if uniform grid sampling were performed.

Number of Total Samples: Calculation Equation and Inputs
The equation used to calculate the number of samples is based on a Sign test (see PNNL 13450 for discussion). For this site, the null hypothesis is rejected in favor of the alternative one if the median(mean) is sufficiently smaller than the threshold. The number of samples to collect is calculated so that if the inputs to the equation are true, the calculated number of samples will cause the null hypothesis to be rejected.

The formula used to calculate the number of samples is:

$$n = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4(SignP - 0.5)^2}$$

where

$$SignP = \Phi\left(\frac{\Delta}{s_{total}}\right)$$

$\Phi(z)$ is the cumulative standard normal distribution on $(-\infty,z)$ (see PNNL-13450 for details),
n is the number of samples,
S_{total} is the estimated standard deviation of the measured values including analytical error,
Δ is the width of the gray region,
α is the acceptable probability of incorrectly concluding the site median(mean) is less than the threshold,
β is the acceptable probability of incorrectly concluding the site median(mean) exceeds the threshold,
$Z_{1-\alpha}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is $1-\alpha$,
$Z_{1-\beta}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is $1-\beta$.

Note: MARSSIM suggests that the number of samples should be increased by at least 20% to account for missing or unusable data and uncertainty in the calculated value of n. VSP allows a user-supplied percent overage as discussed in MARSSIM (EPA 2000, p. 5-33).

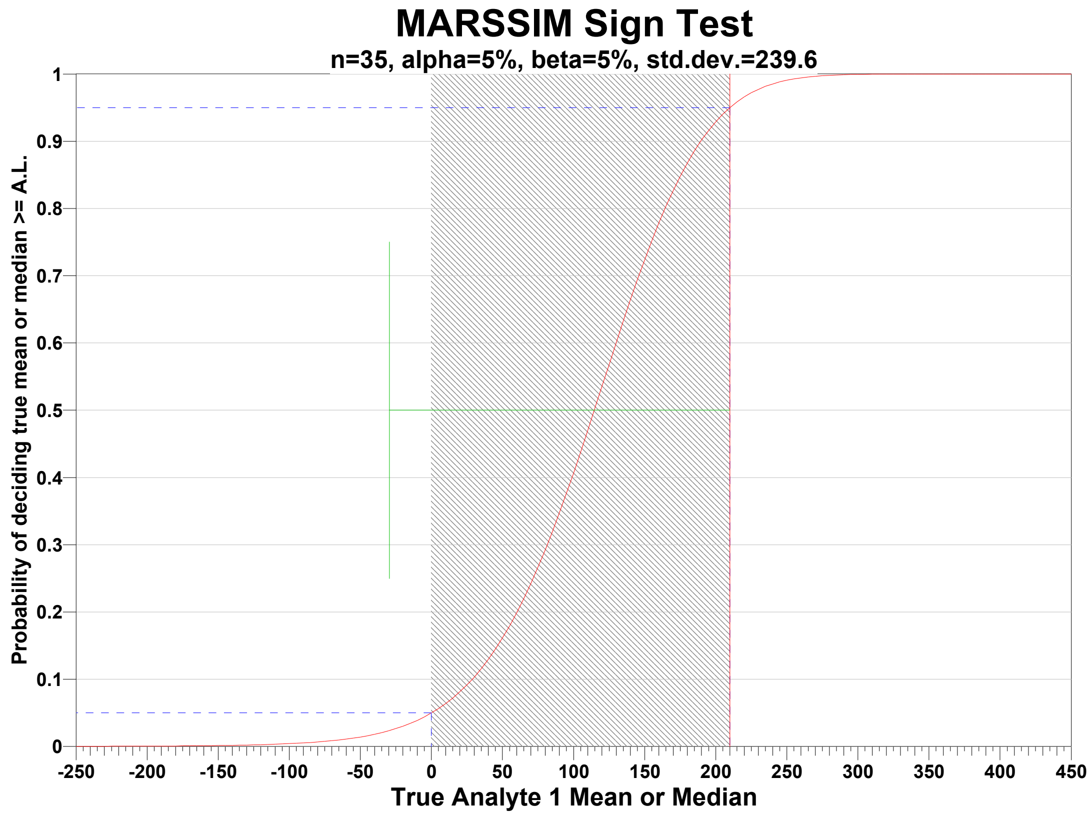
The values of these inputs that result in the calculated number of sampling locations are:

Analyte	**n**[a]	**Parameter**					
		S	**Δ**	**α**	**β**	$Z_{1-\alpha}$ [b]	$Z_{1-\beta}$ [c]
Analyte 1	35	239.6	209.998	0.05	0.05	1.64485	1.64485

[a] The final number of samples has been increased by the MARSSIM Overage of 20%.
[b] This value is automatically calculated by VSP based upon the user defined value of α.
[c] This value is automatically calculated by VSP based upon the user defined value of β.

The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true median(mean) values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the upper horizontal dashed blue line is positioned at $1-\alpha$ on the vertical axis; the lower horizontal dashed blue line is positioned at β on the vertical axis. The vertical green line is positioned at one standard deviation below the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at β and the upper bound of Δ at $1-\alpha$. If any of the inputs change, the number of samples that result in the correct curve changes.



Statistical Assumptions
The assumptions associated with the formulas for computing the number of samples are:
1. the computed sign test statistic is normally distributed,
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected randomly.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the sample locations were selected using a random process.

Sensitivity Analysis
The sensitivity of the calculation of number of samples was explored by varying the standard deviation, lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ > action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples							
AL=210		α=5		α=10		α=15	
		s=479.2	s=239.6	s=479.2	s=239.6	s=479.2	s=239.6
LBGR=90	β=5	10630	2663	8412	2108	7062	1769
	β=10	8412	2108	6453	1617	5278	1323
	β=15	7062	1769	5278	1323	4221	1058

LBGR=80	**β=5**	2663	671	2108	532	1769	447
	β=10	2108	532	1617	408	1323	334
	β=15	1769	447	1323	334	1058	267
LBGR=70	**β=5**	1188	303	940	240	790	202
	β=10	940	240	722	184	591	150
	β=15	790	202	591	150	472	120

s = Standard Deviation
LBGR = Lower Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ > action level
α = Alpha (%), Probability of mistakenly concluding that μ < action level
AL = Action Level (Threshold)

Cost of Sampling
The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is $18,500.00, which averages out to a per sample cost of $528.57. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**35 Samples**
Field collection costs		$100.00	$3,500.00
Analytical costs	$400.00	$400.00	$14,000.00
Sum of Field & Analytical costs		**$500.00**	**$17,500.00**
Fixed planning and validation costs			$1,000.00
Total cost			**$18,500.00**

Data Analysis for Analyte 1
The following data points were entered by the user for analysis.

Analyte 1										
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	0.001	0.001	0.001	0.002	0.0055	0.068	0.08625	0.125	0.1315	0.1315
10	0.133	0.133	0.133	0.1345	0.1345	0.1375	0.1375	0.139	0.2	0.2
20	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	2.5
30	5.8	6	8.1	12	18	47	63	170	240	300
40	1500									

SUMMARY STATISTICS for Analyte 1	
n	41
Min	0.001
Max	1500
Range	1500
Mean	57.962
Median	0.2

Variance	57389
StdDev	239.56
Std Error	37.413
Skewness	5.7618
Interquartile Range	5.7678

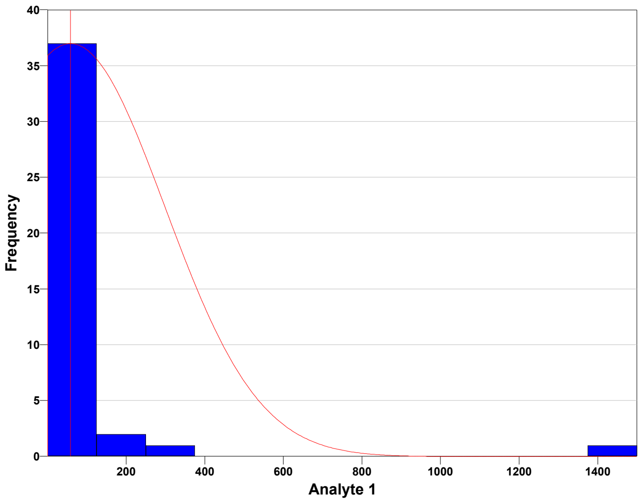
Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
0.001	0.001	0.0027	0.1323	0.2	5.9	148.6	294	1500

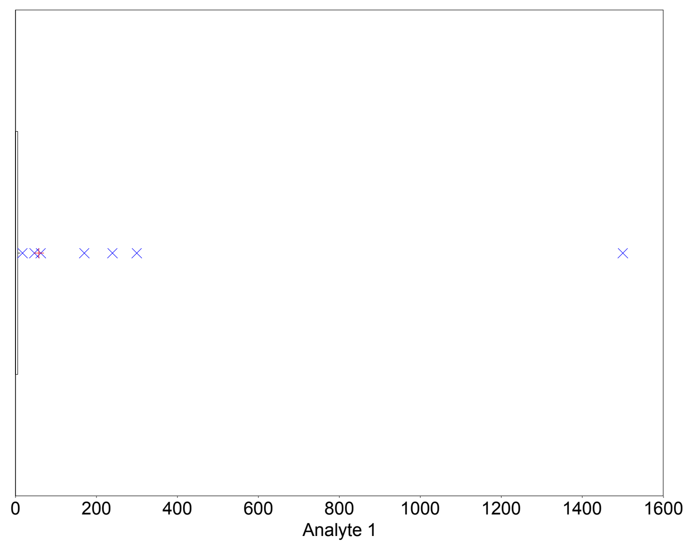
Data Plots
Three graphical displays of the data are shown below: the Histogram, the Box and Whiskers plot, and the Quantile-Quantile (Q-Q) plot.

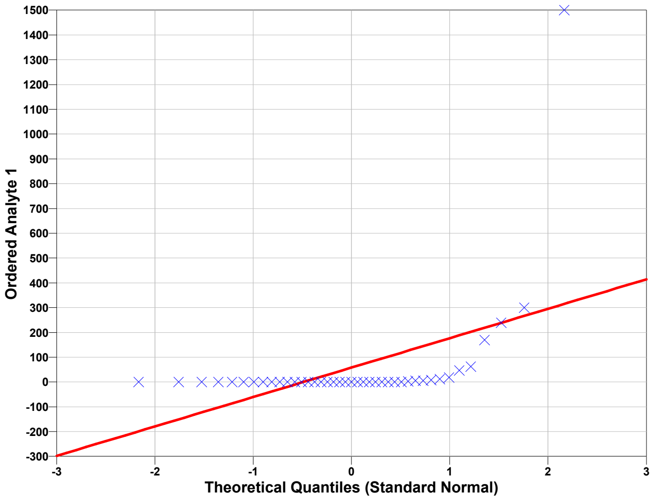
The Histogram is a plot of the fraction of the n observed data that fall within specified data “bins.” A histogram is generated by dividing the x axis (range of the observed data values) into "bins" and displaying the number of data in each bin as the height of a bar for the bin. The area of the bar is the fraction of the n data values that lie within the bin. The sum of the fractions for all bins equals one. A histogram is used to assess how the n data are distributed (spread) over their range of values. If the histogram is more or less symmetric and bell shaped, then the data may be normally distributed.

The Box and Whiskers plot is composed of a central box divided by a line, and with two lines extending out from the box, called the "whiskers". The line through the box is drawn at the median of the n data observed. The two ends of the box represent the 25th and 75th percentiles of the n data values, which are also called the lower and upper quartiles, respectively, of the data set. The sample mean (mean of the n data) is shown as a "+" sign. The upper whisker extends to the largest data value that is less than the upper quartile plus 1.5 times the interquartile range (upper quartile minus the lower quartile). The lower whisker extends to the smallest data value that is greater than the lower quartile minus 1.5 times the interquartile range. Extreme data values (greater or smaller than the ends of the whiskers) are plotted individually. A Box and Whiskers plot is used to assess the symmetry of the distribution of the data set. If the distribution is symmetrical, the box is divided into two equal halves by the median, the whiskers will be the same length, and the number of extreme data points will be distributed equally on either end of the plot.

The Q-Q plot graphs the quantiles of a set of n data against the quantiles of a specific distribution. We show here only the Q-Q plot for an assumed normal distribution. The pth quantile of a distribution of data is the data value, x_p, for which a fraction p of the distribution is less than x_p. If the data plotted on the normal distribution Q-Q plot closely follow a straight line, even at the ends of the line, then the data may be assumed to be normally distributed. If the data points deviate substantially from a linear line, then the data are not normally distributed.







For more information on these three plots consult Guidance for Data Quality Assessment, EPA QA/G-9, pgs 2.3-1 through 2.3-12. (http://www.epa.gov/quality/qa-docs.html).

Tests for Analyte 1
A goodness-of-fit test was performed to test whether the data set had been drawn from an underlying normal distribution. The Shapiro-Wilk (SW) test was used to test the null hypothesis that the data are normally distributed. The test was conducted at the 5% significance level, i.e., the probability the test incorrectly rejects the null hypothesis was set at 0.05.

NORMAL DISTRIBUTION TEST	
Shapiro-Wilk Test Statistic	0.2728
Shapiro-Wilk 5% Critical Value	0.941

The calculated SW test statistic is less than the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the data are normal, or in other words the data do not appear to follow a normal distribution at the 5% level of significance. The Q-Q plot displayed above should be used to further assess the normality of the data.

Upper Confidence Limit on the True Mean
Two methods were used to compute the upper confidence limit (UCL) on the mean. The first is a parametric method that assumes a normal distribution. The second is the Chebyshev method, which requires no distributional assumption.

UCLs ON THE MEAN	
95% Parametric UCL	120.96
95% Non-Parametric (Chebyshev) UCL	221.04

Because the data do not appear to be normally distributed according to the goodness-of-fit test performed above, the non-parametric UCL (221) may be a more accurate upper confidence limit on the true mean.

MARSSIM Sign Test
The Sign test was performed in accordance with the guidance given in section 8.3.2 of MARSSIM. Each measurement was subtracted from the action level to obtain *n* differences $d_i = AL - X_i$. Any differences of zero were discarded from consideration and the sample size was reduced accordingly. The test statistic S+ was calculated by counting the positive differences. S+ was then compared with the critical value *k*, which was obtained from Table I.3 in Appendix I of MARSSIM.

If $S+ > k$, then the null hypothesis is rejected.

MARSSIM SIGN TEST		
Test Statistic S+	**95% Critical Value**	**Null Hypothesis**
38	26	Reject

The test rejected the null hypothesis that the mean value at the site exceeds the threshold, so conclude the site is clean.

APPENDIX D
VSP OUTPUT RESULTS

BENZO(A)PYRENE

Random sampling locations for comparing a median with a fixed threshold (nonparametric - MARSSIM)

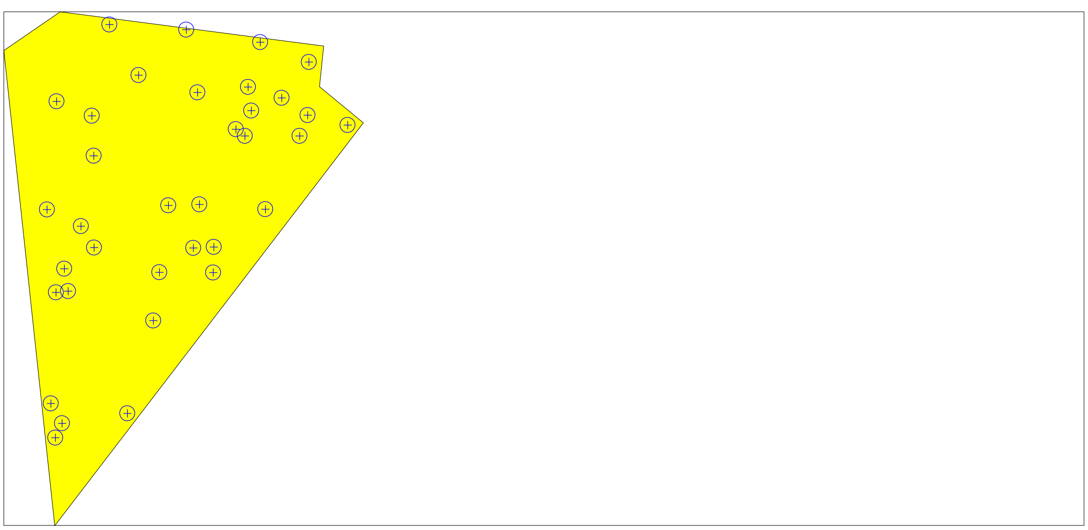
Summary

This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed. A figure that shows sampling locations in the field and a table that lists sampling location coordinates are also provided below.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean or median to a fixed threshold
Type of Sampling Design	Nonparametric
Sample Placement (Location) in the Field	Simple random sampling
Working (Null) Hypothesis	The median(mean) value at the site exceeds the threshold
Formula for calculating number of sampling locations	Sign Test - MARSSIM version
Calculated total number of samples	35
Number of samples on map [a]	35
Number of selected sample areas [b]	1
Specified sampling area [c]	300838.47 ft^2
Total cost of sampling [d]	$18,500.00

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.
[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.
[d] Including measurement analyses and fixed overhead costs. See the Cost of Sampling section for an explanation of the costs presented here.



Area: Area 1

X Coord	Y Coord	Label	Value	Type	Historical
1787401.6145	10660375.9317	R-SO-4	0.004	Random	
1787352.4212	10660028.1948	R-SO-5	0.275	Random	
1787812.5385	10660202.3308	R-SO-6	0.269	Random	
1787534.4561	10660366.8469	R-SO-7	0.263	Random	
1787640.9692	10660268.0009	R-SO-8	0.266	Random	
1787477.2445	10659864.9170	R-SO-9	0.275	Random	
1787371.3697	10660218.6753	R-SO-11	0.263	Random	
1787581.5886	10659991.9816	R-SO-12	0.266	Random	
1787556.8177	10660065.3830	R-SO-13/14 Average	0.1725	Random	
1787745.8636	10660311.2318	R-SO-16	0.002	Random	
1787743.6815	10660219.7401	R-SO-17	0.011	Random	
1787619.5519	10660195.1275	R-SO-18	0.25	Random	
1787293.8287	10660056.5762	R-SO-19	0.269	Random	
1787635.1321	10660183.6688	R-SO-20	0.278	Random	
1787310.5248	10660243.0616	R-SO-21	0.266	Random	
1787546.2921	10659990.7000	R-SO-22	0.068	Random	
1787374.9415	10659991.2351	R-ERM-SB-6	170	Random	
1787308.3592	10659662.7936	R-ERM-SB-8	63	Random	
1787323.7305	10659954.4557	R-ERM-SB-11	47	Random	
1787374.4312	10660149.5224	R-ERM-SB-12	240	Random	
1787646.1733	10660227.4683	T-SO-1	0.002	Random	
1787300.4606	10659722.3984	T-SO-2	0.002	Random	
1787670.8295	10660057.1869	T-2	0.6	Random	
1787309.6988	10659913.9155	T-4	0.6	Random	
1787729.4654	10660183.6540	T-MW1 15-16'	8.1	Random	
1787580.4792	10659947.9712	T-MW1 39-40'	0.4	Random	
1787320.1381	10659687.6246	T-B3 10-12	2.5	Random	
1787553.6874	10660258.8400	T-B3 42-43	0.4	Random	
1787698.7129	10660249.4312	T-MW2 14-16'	6	Random	
1787487.7705	10659948.7117	T-MW2 40-42'	0.4	Random	
1787452.0451	10660288.7602	T-B4 10-12'	5.8	Random	
1787503.2452	10660063.7650	T-B4 42'	0.4	Random	
1787330.5593	10659915.9673	T-B4 0-2'	0.4	Random	
1787661.6851	10660345.2338	T-B4 12-14'	0.4	Random	
1787432.8218	10659704.7377	T-MW3 17-19'	1500	Random	

Primary Sampling Objective
The primary purpose of sampling at this site is to compare a site median or mean value with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the median(mean) value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the median(mean) value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative one, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach
A nonparametric random sampling approach was used to determine the number of samples and to specify sampling locations. A nonparametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that typical parametric assumptions may not be true.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

Locating the sample points randomly provides data that are separated by many distances, whereas systematic samples are all equidistant apart. Therefore, random sampling provides more information about the spatial structure of the potential contamination than systematic sampling does. As with systematic sampling, random sampling also provides information regarding the mean value, but there is the possibility that areas of the site will not be represented with the same frequency as if uniform grid sampling were performed.

Number of Total Samples: Calculation Equation and Inputs
The equation used to calculate the number of samples is based on a Sign test (see PNNL 13450 for discussion). For this site, the null hypothesis is rejected in favor of the alternative one if the median(mean) is sufficiently smaller than the threshold. The number of samples to collect is calculated so that if the inputs to the equation are true, the calculated number of samples will cause the null hypothesis to be rejected.

The formula used to calculate the number of samples is:

$$n = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4(SignP - 0.5)^2}$$

where

$$SignP = \Phi\left(\frac{\Delta}{s_{total}}\right)$$

$\Phi(z)$ is the cumulative standard normal distribution on $(-\infty, z)$ (see PNNL-13450 for details),
n is the number of samples,
S_{total} is the estimated standard deviation of the measured values including analytical error,
Δ is the width of the gray region,
α is the acceptable probability of incorrectly concluding the site median(mean) is less than the threshold,
β is the acceptable probability of incorrectly concluding the site median(mean) exceeds the threshold,
$Z_{1-\alpha}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is $1-\alpha$,
$Z_{1-\beta}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is $1-\beta$.

Note: MARSSIM suggests that the number of samples should be increased by at least 20% to account for missing or unusable data and uncertainty in the calculated value of n. VSP allows a user-supplied percent overage as discussed in MARSSIM (EPA 2000, p. 5-33).

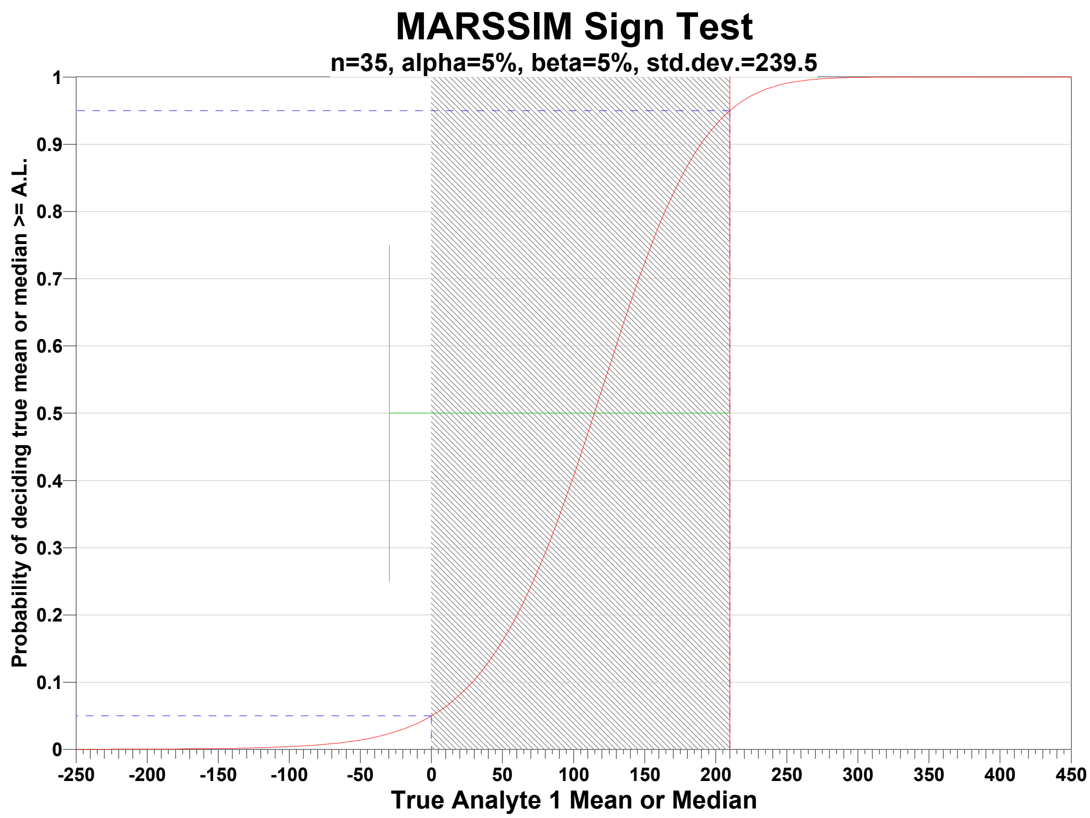
The values of these inputs that result in the calculated number of sampling locations are:

Analyte	n[a]	Parameter					
		S	Δ	α	β	$Z_{1-\alpha}$ [b]	$Z_{1-\beta}$ [c]
Analyte 1	35	239.5	209.998	0.05	0.05	1.64485	1.64485

[a] The final number of samples has been increased by the MARSSIM Overage of 20%.
[b] This value is automatically calculated by VSP based upon the user defined value of α.
[c] This value is automatically calculated by VSP based upon the user defined value of β.

The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true median(mean) values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the upper horizontal dashed blue line is positioned at $1-\alpha$ on the vertical axis; the lower horizontal dashed blue line is positioned at β on the vertical axis. The vertical green line is positioned at one standard deviation below the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at β and the upper bound of Δ at $1-\alpha$. If any of the inputs change, the number of samples that result in the correct curve changes.



Statistical Assumptions
The assumptions associated with the formulas for computing the number of samples are:

1. the computed sign test statistic is normally distributed,
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected randomly.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the sample locations were selected using a random process.

Sensitivity Analysis
The sensitivity of the calculation of number of samples was explored by varying the standard deviation, lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ > action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples							
AL=210		α=5		α=10		α=15	
		s=479	s=239.5	s=479	s=239.5	s=479	s=239.5
LBGR=90	β=5	10622	2661	8405	2106	7056	1768
	β=10	8405	2106	6448	1616	5273	1322
	β=15	7056	1768	5273	1322	4217	1058

LBGR=80	**β=5**	2661	671	2106	531	1768	446
	β=10	2106	531	1616	408	1322	334
	β=15	1768	446	1322	334	1058	267
LBGR=70	**β=5**	1187	303	940	239	789	201
	β=10	940	239	720	184	590	150
	β=15	789	201	590	150	472	120

s = Standard Deviation
LBGR = Lower Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ > action level
α = Alpha (%), Probability of mistakenly concluding that μ < action level
AL = Action Level (Threshold)

Cost of Sampling
The total cost of the completed sampling program depends on several cost inputs, some of which are fixed, and others that are based on the number of samples collected and measured. Based on the numbers of samples determined above, the estimated total cost of sampling and analysis at this site is $18,500.00, which averages out to a per sample cost of $528.57. The following table summarizes the inputs and resulting cost estimates.

COST INFORMATION			
Cost Details	**Per Analysis**	**Per Sample**	**35 Samples**
Field collection costs		$100.00	$3,500.00
Analytical costs	$400.00	$400.00	$14,000.00
Sum of Field & Analytical costs		**$500.00**	**$17,500.00**
Fixed planning and validation costs			$1,000.00
Total cost			**$18,500.00**

Data Analysis for Analyte 1
The following data points were entered by the user for analysis.

Analyte 1										
Rank	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	0.002	0.002	0.002	0.004	0.011	0.068	0.1725	0.25	0.263	0.263
10	0.266	0.266	0.266	0.269	0.269	0.275	0.275	0.278	0.4	0.4
20	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.6	0.6	2.5
30	5.8	6	8.1	12	18	47	63	170	240	300
40	1500									

SUMMARY STATISTICS for Analyte 1	
n	41
Min	0.002
Max	1500
Range	1500
Mean	58.059
Median	0.4

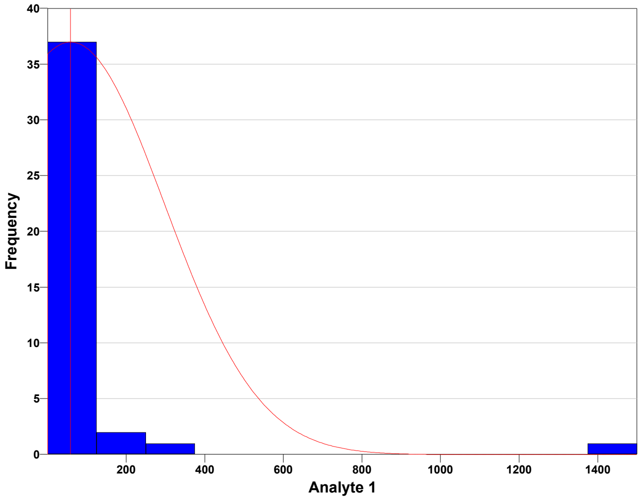
Variance					57377			
StdDev					239.54			
Std Error					37.409			
Skewness					5.7623			
Interquartile Range					5.6355			
Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
0.002	0.002	0.0054	0.2645	0.4	5.9	148.6	294	1500

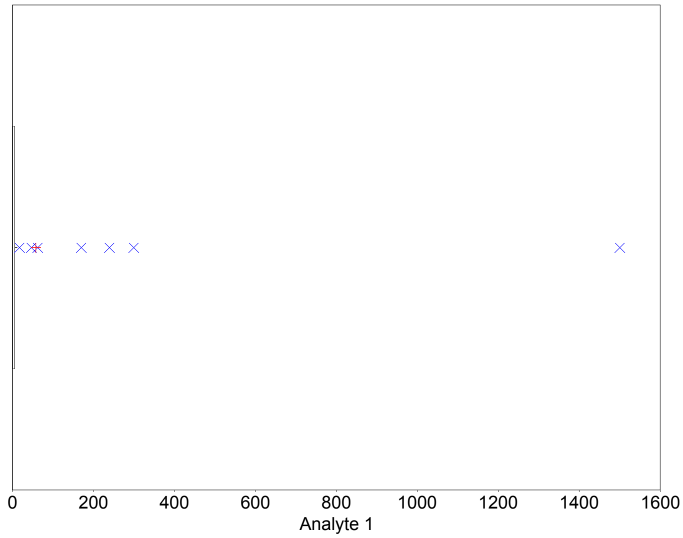
Data Plots
Three graphical displays of the data are shown below: the Histogram, the Box and Whiskers plot, and the Quantile-Quantile (Q-Q) plot.

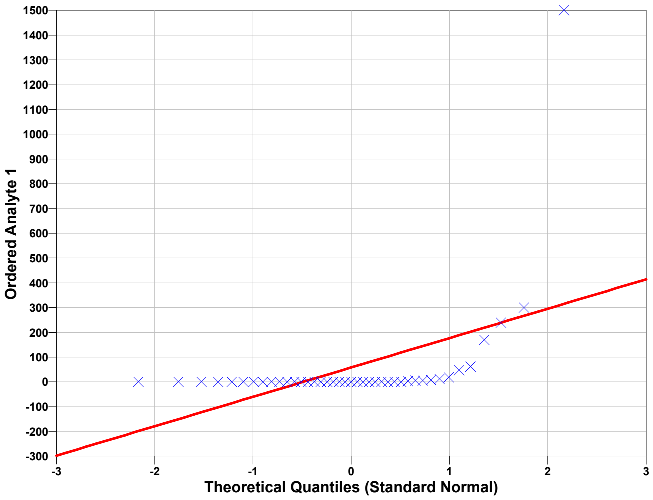
The Histogram is a plot of the fraction of the n observed data that fall within specified data “bins.” A histogram is generated by dividing the x axis (range of the observed data values) into "bins" and displaying the number of data in each bin as the height of a bar for the bin. The area of the bar is the fraction of the n data values that lie within the bin. The sum of the fractions for all bins equals one. A histogram is used to assess how the n data are distributed (spread) over their range of values. If the histogram is more or less symmetric and bell shaped, then the data may be normally distributed.

The Box and Whiskers plot is composed of a central box divided by a line, and with two lines extending out from the box, called the "whiskers". The line through the box is drawn at the median of the n data observed. The two ends of the box represent the 25th and 75th percentiles of the n data values, which are also called the lower and upper quartiles, respectively, of the data set. The sample mean (mean of the n data) is shown as a "+" sign. The upper whisker extends to the largest data value that is less than the upper quartile plus 1.5 times the interquartile range (upper quartile minus the lower quartile). The lower whisker extends to the smallest data value that is greater than the lower quartile minus 1.5 times the interquartile range. Extreme data values (greater or smaller than the ends of the whiskers) are plotted individually. A Box and Whiskers plot is used to assess the symmetry of the distribution of the data set. If the distribution is symmetrical, the box is divided into two equal halves by the median, the whiskers will be the same length, and the number of extreme data points will be distributed equally on either end of the plot.

The Q-Q plot graphs the quantiles of a set of n data against the quantiles of a specific distribution. We show here only the Q-Q plot for an assumed normal distribution. The pth quantile of a distribution of data is the data value, x_p, for which a fraction p of the distribution is less than x_p. If the data plotted on the normal distribution Q-Q plot closely follow a straight line, even at the ends of the line, then the data may be assumed to be normally distributed. If the data points deviate substantially from a linear line, then the data are not normally distributed.







For more information on these three plots consult Guidance for Data Quality Assessment, EPA QA/G-9, pgs 2.3-1 through 2.3-12. (http://www.epa.gov/quality/qa-docs.html).

Tests for Analyte 1
A goodness-of-fit test was performed to test whether the data set had been drawn from an underlying normal distribution. The Shapiro-Wilk (SW) test was used to test the null hypothesis that the data are normally distributed. The test was conducted at the 5% significance level, i.e., the probability the test incorrectly rejects the null hypothesis was set at 0.05.

NORMAL DISTRIBUTION TEST	
Shapiro-Wilk Test Statistic	0.2728
Shapiro-Wilk 5% Critical Value	0.941

The calculated SW test statistic is less than the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the data are normal, or in other words the data do not appear to follow a normal distribution at the 5% level of significance. The Q-Q plot displayed above should be used to further assess the normality of the data.

Upper Confidence Limit on the True Mean
Two methods were used to compute the upper confidence limit (UCL) on the mean. The first is a parametric method that assumes a normal distribution. The second is the Chebyshev method, which requires no distributional assumption.

UCLs ON THE MEAN	
95% Parametric UCL	121.05
95% Non-Parametric (Chebyshev) UCL	221.12

Because the data do not appear to be normally distributed according to the goodness-of-fit test performed above, the non-parametric UCL (221.1) may be a more accurate upper confidence limit on the true mean.

MARSSIM Sign Test
The Sign test was performed in accordance with the guidance given in section 8.3.2 of MARSSIM. Each measurement was subtracted from the action level to obtain *n* differences $d_i = AL - X_i$. Any differences of zero were discarded from consideration and the sample size was reduced accordingly. The test statistic S+ was calculated by counting the positive differences. S+ was then compared with the critical value *k*, which was obtained from Table I.3 in Appendix I of MARSSIM.

If $S+ > k$, then the null hypothesis is rejected.

MARSSIM SIGN TEST		
Test Statistic S+	**95% Critical Value**	**Null Hypothesis**
38	26	Reject

The test rejected the null hypothesis that the mean value at the site exceeds the threshold, so conclude the site is clean.